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APPLIED MECHANICS REVIEWS

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EARTHQUAKE RESISTANT DESIGN

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Historical Background

Nearly 50 years ago Naito began designing for lateral loads assumed to be a fraction of the weight of each floor or element in the building. These structures withstood the 1923 Tokyo-Yokohama earthquake satisfactorily while many other modern buildings collapsed or suffered severe damage. Success popularized Naito's method.

Most building codes still require that lateral forces be computed as a seismic coefficient times the weight. Usually the coefficient is assumed to be constant throughout the height of the structure. This implies uniform horizontal acceleration, hence a rigid building on a rigid base. But inertia forces produce deformations in structure and soil; therefore the method is implicitly contradictory. In order better to approximate results of dynamic analysis and conclusions derived from observed damage, several codes specify seismic coefficients that increase with elevation above ground, thus crudely taking into consideration the deformation of the structure and soil.

Earthquake Spectra

During the early 1930's the main variables were well recognized and the problem forcefully stated (1, 2). The bases for dynamic analysis and rational methods of design were laid down by various authors, mainly in Biot's classical paper (3). Their chief contribution was the development of the concept of earthquake spectra (plots of maximum numerical values of responses of linear systems with one degree of freedom, as functions of their natural periods). Variations of this approach found practical applications in design (4). Other attempts at development of methods of dynamic analysis, though popular, oversimplified the assumed ground motions.

Computation of spectra has been accomplished by means of mechanical (6) and electrical (5) analogs and digital computers (7). In mechanical analogs damping is not adequately controlled, so results are inaccurate. The other two methods have proved successful.

Computation of spectra from earthquake records is no longer likely to introduce important errors but the records themselves are debatable.

No complete record of a major shock is available because of the lag required to trigger recording instruments. A second source of uncertainty arises from shifts in the zero line and distorsion of the recording paper as it is processed. According to the emphasis laid on these two causes different methods have been proposed to adjust records, making the end ground velocity zero and reducing velocities at intermediate times to reasonable values. One method uses fictitious additional initial pulses (8), while another adjusts the zero line adding a polynomial correction derived by least squares (7). Statistically, errors introduced by adjustment procedures are not serious in the usual range of natural periods. But published spectrum ordinates for periods in excess of about 3 sec are suspect. Not until recording methods are refined for strong motions will reliable spectra become available.

One procedure for recording the portion of the accelerogram that precedes action of the trigger mechanism has been successfully used at the Earthquake Research Institute, Tokyo University. It consists in a closed loop magnetic tape whose record is continuously erased until the trigger acts; it is then passed onto a definitive record.

Biot (3) proposed basing design on envelopes of spectra of past earthquakes. In principle, if accurate acceleration spectra were available in sufficient numbers one could draw their envelope for each locality and read directly the design accelerations for structures idealizable as linear and having a single degree of freedom. However, many records of strong motions have been obtained from instruments located in substantial structures and hence do not measure the motion of free ground surface. There are indications that spectra computed therefrom greatly overestimate structural responses in certain ranges of natural periods and that, rather than basing design on peaks of spectra, they should be based on the ordinates of the valleys (8, 9).

In practice, scarcity of strong-motion records precludes development of design methods based on spectrum envelopes. One is thus led to a probabilistic treatment of the problem. In 1947 Housner pointed out the randomness of earthquake motions and suggested idealization as series of random instantaneous or brief pulses (10). The idealization permitted construction of fictitious motions by use of random numbers (11) and electric analogs (12, 13). Statistical analysis of responses to these motions has led to some general conclusions concerning linear and nonlinear systems.

Random continuous functions of time, borrowed from the theory of communications, have also been proposed (14), and hold more promise than random pulses. Refinements must be incorporated before fictitious motions can be regarded as representative of strong earthquakes. Moreover, some earthquakes have consisted of a single short pulse (15) and are therefore not of random nature.

Idealization as arrays of pulses has also led to developments based on the theory of probabilities, applicable to linear systems with one or more degrees of freedom (11). The distributions of responses calculated correspond to ground

motions of specified expected undamped spectrum and intensity. Borges (16) has pointed out that the dispersion of intensities of future motions will mask the distribution of responses to a motion of known intensity. It is therefore necessary to calculate combined distributions. Some studies have been published on microregionalization and regional seismicity, correlation between magnitude, energy, and intensity, probability distributions of these variables, and influence of geology on shape of expected spectra (17–20). Much remains to be done before probability distributions of responses to future motions of unknown intensity and spectrum can be satisfactorily computed.

Applications of the concept of spectrum have been limited to motion in a single direction. Apparently no attempt has been made to generalize to simultaneous ground displacements along three orthogonal components, and accelerograms of rotational ground motions have not been recorded.

Linear Systems

Under most practical conditions the response of linear systems with several degrees of freedom can be treated approximately as the superposition of those associated with their natural modes of vibration. Each mode behaves as a system with one degree of freedom; earthquake spectra provide the maximum response associated with each natural period, but not the instants at which these maxima occur. The probability of their simultaneous occurrence is nil. Hence, the arithmetic sum of maximum modal responses overestimates the maximum response of the system. The error is not often serious but may become inadmissible.

Probability analysis leads to an approximate relationship in which the design response of the system is equal to the square root of the sum of squares of the maxima associated with the system's natural modes (11). In typical buildings with several degrees of freedom the relationship yields good results (21). However, under some conditions it, too, may entail excessive errors.

Actually, no method of modal analysis is satisfactory for certain linear systems. This is the case when two or more natural periods are nearly equal and the responses of the corresponding modes to a transient disturbance have opposite signs. Then decomposition into natural modes and recombination of the respective maximum numerical values (by either of the methods mentioned above) greatly overestimates the maximum combined response. An example is found in the torsion of buildings having rigidities in the neighborhood of critical values (22). It is likely that these problems can be solved adequately by statistical analysis of computed responses to series of actual or realistically simulated earthquake records.

A similar approach is indicated in linear systems when criteria of failure involve nonlinear functions of responses. Again modal analysis cannot be applied.

Attempts have been made at analyzing linear systems by methods of the theory of communications (14). No practical conclusions can yet be derived, due to complexity of the analytical developments and to the fact that in earthquake resistant design maximum responses play a more important role than expected mean squares of the responses (23).

Nonlinear Systems

Methods have been developed for accurate analysis of nonlinear systems. They include graphic procedures, electric analogs (5, 13), and general numerical procedures (24). Availability of these methods has produced the publication of numerous papers of exploratory nature, concerned with the comparison of elastic and elastoplastic responses of certain structures to specific actual or fictitious earthquake records. Results are difficult to generalize much beyond the conclusion that, ordinarily, elastoplastic structures undergo maximum displacements of the same order or smaller than those of elastic systems having the same natural periods and degrees of viscous damping.

There have been advances in the field of behavior of materials under earthquake-type loading, especially soils and reinforced-concrete structures. Still, present criteria of failure are open to question. Some researchers advocate basing design on the energy absorbed by the system (25). This is perhaps too conservative for systems subjected to a single earthquake but tends to account for accumulation of damage in successive quakes. Through application of this approach, Housner (26) has compared equivalent seismic coefficients for various rigid-plastic structures. He has shown that inverted pendulums are more vulnerable than frames and that some symmetric structures are capable of collapse in torsion.

Another design criterion for systems idealized as elastoplastic rests on the *ductility factor* (27). This factor is the ratio of ultimate to yield-point displacement. It is proposed that structures be designed so that a permissible ductility factor not be exceeded. The criterion is probably adequate for a few cycles of loading and must be adjusted to account for cumulative damage.

A third approach is the "reserve energy technique" (28). It must still be improved to apply with generality to systems with several degrees of freedom.

Hydrodynamic Problems

Vibrations of submerged structures are usually dealt with by assuming that the structure has the same stiffness and damping as if it were in air but possessing an additional virtual mass of liquid, which is computed according to simplified rules based on rigorous theories (9, 29). The procedure is in most case surprisingly accurate even under transient disturbances (30).

Vibration of fluid in tanks is the subject of a general numerical procedure (31), and of analytical and experimental work (29, 32).

Westergaard's classical paper on hydrodynamic pressures against dams (33) has been extended to sloping profiles (34); to cylindrical dams having vertical upstream face (35); and to transient disturbances (35).

Soil Conditions

Attention has been given to the question of filtering of seismic waves as they traverse soft mantles (36, 37). Most studies assume that mantle and base rock are elastic or viscoelastic and often that the problem can be reduced to one of plane waves. Analysis predicts pronounced magnification of waves within narrow bands of prevailing ground periods.

These theories have received very good experimental confirmation (38). The motions in question have, however, been of low intensity. Gutenberg's extensive measurements on the influence of geologic conditions (39) were also limited to tremors and showed marked effects of soil properties. There is doubt that such results can be extrapolated to destructive earthquakes (20): pronounced prevailing ground periods during macroseisms have been reported only under the peculiar conditions of the 1957 earthquake in Mexico City (40).

Soil liquefaction has been a major source of damage. Available empirical rules point out soils that are likely to liquefy but ignore the effects of many obviously important variables. Work in this field has been descriptive. The same applies to the related phenomena of flow slides and, in general, of slides of large soil masses, often lubricated by air or water.

Sporadic work has been done on elastic properties of soils subjected to dynamic loads (41, 42) and conditions of failure under single or repeated rapid loading (43).

Foundation compliance was studied by Biot under simplifying assumptions, neglecting soil mass (3). Better ap-

proximations have been recently proposed (44). Some experimental information is available from forced vibrations of buildings and earthquake records (45, 46). The phenomenon is often unimportant (47), as has been confirmed in specific instances, but becomes decisive in rigid, slender buildings and other structures on soft soil.

Buildings

Of all types of structures, buildings have received the greatest share of attention in earthquake-resistant design. Much of it has gone into devising empirical and semiempirical formulas for the estimation of natural periods, and distributions of static lateral loads for design, "equivalent" to results of dynamic analyses (e.g., Ref. 48). Although present tendencies are toward dynamic analysis, limitations derived from the usual assumption of linear behavior and insufficient information on structural behavior justify wide acceptance of the cruder methods. Recognition of differences in energy absorption capacity of various structural systems, based mostly on judgment, has been incorporated in some building codes (49, 50).

Forced vibration tests (45, 51, 52), and some laboratory work have begun to throw light on the rigidity and behavior of structural elements, including filler walls and other "nonstructural" elements.

Moot questions include that of drift limitations. Psychological consequences of lateral deflection are still treated qualitatively. On the other hand, much has been advanced in predicting the relative displacements that cause nonstructural damage, such as glass breakage (53), and devising construction details to isolate and protect nonstructural elements from the deformations of structural frames (54).

Dynamic torsion, computed by modal analysis, may greatly exceed the values computed statically (22, 55). But, precisely in the critical range, modal analysis breaks down. Further, inelastic behavior probably reduces the computed dynamic magnification. "Accidental" torsion (mainly from accidental differences between nominal and actual rigidities and hence uncertainty in the location of the center of torsion) is known to be potentially dangerous. Rules tending to account for these factors (49, 50) are based on judgment. The same applies to methods for treating setbacks (49).

Overturning moments are overestimated when computed from the set of static horizontal loads intended to supply the envelope of design seismic shears, chiefly because the maximum shears have zero probability of occurring simultaneously. Methods (49) based on quantitative analyses (some of which apply also to stack-like structures) (56) have begun to supplant arbitrary reduction procedures in building codes.

Other Structures

Nuclear reactors (57), suspension bridges, and concrete dams are being designed assuming linear behavior. Four reasons justify this practice: importance of the structures, their usually long natural periods, low cost of introducing earthquake resistance, and inexperience with their behavior under strong shocks. Arch dams present the greatest difficulties: field measurements (58) indicate strongly nonlinear behavior caused by contraction joints and abutment conditions, which invalidate extrapolation from analytical and model test results.

In structures such as large dams and bridges, seismic waves at opposite abutments may be quite out of phase. Analytical methods are yet to be devised to include this feature.

Earth and rock-fill dams have caused controversy. Some (59) advocate the assumption of elastic behavior. Accordingly, methods have been developed for calculation of natural modes (59, 60). Others advocate assumption of rigid-plastic behavior, and some progress has been achieved in development of the corresponding analytical methods (61). Probably the first approach is justified when there is danger of collapse, which may occur when dam materials are subject to flow slides. According to model tests in a shaking table (62) the second method is more realistic when materials used do not reduce their strength under progressive deformation after reaching peak strength. Modern practice tends toward (but does not always attain) exclusive use of such materials. Model test results indicate that collapse is then virtually impossible, and design should be based on allowable loss of free board.

Design of structures subjected to dynamic earth pressure must be based on extrapolation from experimental data. The matter of seismic pore pressures in these structures and in earth and rock-fill dams seems to be imperfectly understood.

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The textbook is lucidly written with excellent problems at the end of various sections to test the student's understanding of the subject matter as well as supplementary problems which round out the treatment. Although the author considers a course in advanced calculus sufficient for a successful reading of the text, the reviewer feels that, in addition, courses in vector analysis and differential equations would be helpful in giving the student the necessary mathematical maturity for a full appreciation of the material discussed. In any case, the book is highly recommended.

E. J. Scott, USA

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O. Gurel, USA

Book—6453. Smirnow, W. I., Curriculum of higher mathematics [Lehrgang der höheren Mathematik], Vol. 3, Part 2, Berlin, VEB Deutscher Verlag der Wissenschaften, 1959, xii + 599 pp., DM 24.80.

The second part of the above volume consists of chapters: 1. Elements of function theory, pp. 1-94. 2. Conformal mapping and plane fields, pp. 95-180. 3. Application of residue theory, entire and discontinuous functions, pp. 181-258. 4. Functions with many variables and functions of matrices, pp. 259-294. 5. Linear differential equations, pp. 295-410. 6. Special functions of mathematical physics, pp. 411-562. Appendix. Reduction of matrices to canonical form, pp. 563-586.

O. Gurel, USA

6454. Leipholz, H., A foundation of the application of the Laplace transform to nonlinear differential equations (in German), *ZAMM* **41,** 5, 208-214, May 1961.

The differential equation $D(x) = f(x, \dot{x}) + z(t)$ under the initial conditions $x^{(i)}(0) = c_i$, $1 \leq i \leq n-1$ is considered. D is an n^{th}-order ($n \geq 2$) linear differential operator with constant coefficients. f is assumed to involve no linear functions of its arguments. Despite nonlinearity, Laplace transforms combined with a successive approximation technique are used after suitable restrictions on z and f are imposed. The applicability of the Laplace transform is proved. Then the convergence of successive approximations is shown and followed by a discussion of error estimates. The basic iteration formula is

$$x_{k+1}(t) = \mathfrak{L}^{-1}\left\{\frac{M_{ax}(s) + \mathfrak{L}\{f(x_k, \dot{x}_k)\} + Z(s)}{D(s)}\right\}$$

where $M_{ax}(s)$ is the polynomial corresponding to the initial conditions, $Z(s) = \mathfrak{L}(z(t))$, $D(s)$ is the polynomial corresponding to the operator D.

B. R. Gelbaum, USA

6455. Bogoliubov, N. N., Medvedev, B. V., and Tavkhelidze, A. N., The application of the methods of N. I. Muskhelishvili to the solution of singular integral equations in quantum field theory, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 39-55.

Authors start with a short physical introduction explaining the character and formulation of the problems which arise in title subject. The basic entity with which one operates in quantum field theory in the problem of the interaction of elementary particles is the operator which transforms the initial state into the final state, the so-called scattering matrix. Starting from the general requirements which must be imposed on this matrix from a physical point of view, namely relativistic covariance, unity and microcausality, it is possible to reduce the problem of finding the scattering matrix to the solution of an infinite system of coupled integral equations with singular kernels. Considering a process in which only a few particles of not too high energies take part, one arrives in a first approximation at a single integral equation determining the amplitude of the interesting process, or at a system of several (two, three) integral equations, jointly determining the amplitudes of several closely interrelated processes. In a number of important cases these equations are found to belong to a class studied by N. I. Muskhelishvili and they can be solved by the methods developed by him. Two examples are given: the photo-production of π-mesons on nucleons and the decay of a neutral K-meson into two π-mesons.

J. Lense, Germany

6456. Vekua, N. P., Linear integro-differential equations with small parameters for higher derivatives, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 592-601.

Author considers integrodifferential equations with small parameters preceding the highest derivatives which have the form

$$\sum_{k=1}^{l} a_{m+k}\varepsilon^k \rho_\varepsilon^{(m+k)}(t) + a_m \rho_\varepsilon^{(m)}(t) +$$

$$\sum_{j=0}^{m-1} [a_j(t)\rho_\varepsilon^{(j)}(t) + \int_0^t K_j(t,\tau)\rho_\varepsilon^{(j)}(\tau)d\tau] = f_\varepsilon(t),$$

where $a_{m+k}(k = 0, 1, \ldots, l)$ are constants, $a_{m+l} = 1$, $a_m \neq 0$, $m > 0$, ε is a small parameter ($\varepsilon > 0$), $a_j(t)$ and $K_j(t, \tau)$ ($j = 0, 1, \ldots, m-1$) are continuous functions in the interval $[0, 1]$ and $f_\varepsilon(t)$ is a given continuous function admitting the decomposition $f_\varepsilon(t) = f(t) + 0(\varepsilon)$. He formulates the Cauchy problem for these equations as follows: To find the solution of the equation for the initial values $\rho^{(j)}(0) = Dj$ ($j = 0, 1, \ldots, m+l-1$), where Dj are arbitrarily given constants.

Assuming that the supplementary characteristic equation $\sum_{k=0}^{l} a_{m+k}\nu^k = 0$ has no multiple roots $\nu_k (k = 1, 2, \ldots, l)$ and that $Re\ \nu_k < 0$, he shows that under these conditions $\lim_{\varepsilon \to 0} \rho_\varepsilon(t) = \rho(t)$, where $\rho(t)$ is the solution of the so-called degenerate equation which is obtained from the given equation for $\varepsilon = 0$ with the same Cauchy problem. An analogous result is obtained by substituting the kernels $K_j(t, \tau)$ by $\frac{\Gamma j(t, \tau)}{\tau - t}$, where $\Gamma j(t, \tau)$ satisfy a Hölder condition with respect to both variables in the interval $[0, 1]$.

J. Lense, Germany

6457. Wishart, D. M. G., Queuing systems in which the discipline is "last-come, first-served," *Operat. Res.* **8,** 5, 591-599, Sept./Oct. 1960.

A typical illustration of the considered queuing system is that of a warehouse where goods are stocked upwards, the unit on top every now and then being taken to fulfill an order.

Waiting-time distributions are discussed under queue disciplines of customers (i.e. the units of material) in a single-server queuing system with Poisson input and general service time. Typical of these disciplines are those denoted by Kendall ["Stochastic processes in the theory of queues," *Ann. Math. Stat.* **24,** 338-354, 1953] as M/G/1 and G1/M/1.

Assumed are steady-state conditions.

A. C. de Kock, Netherlands

Book—6458. The new mathematics (Reprint of feature articles appearing in *Prod. Engng.* 1955-1960), New York, McGraw-Hill Publishing Co. Inc., 64 pp. $2. (Paperbound)

Book—6459. Boyer, C. B., The history of the calculus and its conceptual development, New York, Dover Publications, Inc., 1959, 346 pp. $2. (Paperbound)

Book—6460. Rouse Ball, W. W., A short account of the history of mathematics, New York, Dover Publications, Inc., 1960, xxiv + 522 pp. $2. (Paperbound)

6461. Hochstadt, H., Asymptotic estimates for the Sturm-Liouville spectrum, AFOSR 276 (New York Univ., Inst. Math. Sci. Res. Rep. BR-36), 26 pp., Feb. 1961.

Computing Methods and Computers

(See also Revs. 6449, 6458, 6491, 6496, 6552, 6623, 6634, 6745, 6858, 6860, 6880)

6462. Rouse, C. A., A method for the numerical calculation of hydrodynamic flow and radiation diffusion by implicit differencing, *J. Soc. Indust. Appl. Math.* **9,** 1, 127-135, Mar. 1961.

In the analysis of such phenomena as exploding wires, strong shocks and the initial phases of blasts, a system is encountered in which there are coupled hydrodynamic flow and radiation diffusion. When solutions are sought by numerical methods, the radiation diffusion has been handled by an implicit differencing scheme while the hydrodynamics has been handled by an explicit differencing scheme. In order to take full advantage of implicit differencing techniques, with the very attractive feature that the stability conditions are independent of the time and space steps ... the author presents a method for solving a coupled hydrodynamic and radiation diffusion system.

From author's summary by G. L. Mellor, USA

6463. Schmidt, J. W., Convergence investigation and error estimation of a generalized method of iteration (in German), *Arch. Rational Mech. Anal.* **6,** 4, 261-276, Dec. 1960.

Iterative processes are frequently used for solving a variety of mathematical problems—linear and nonlinear systems of equations, ordinary and some partial differential equations, etc. They may be generally described as applying some *procedure* (or "operator") T first to an assumed initial approximation x_0 to the desired solution, and then successively to the results of the procedure T itself, thus: $x_0, Tx_0 = x_1, \ldots, Tx_n = x_{n+1}, \ldots$ (Here Tx denotes the results of applying the procedure T to the element x.) Schmidt investigates a more general kind of process, in which there is a sequence of procedures $T_0, T_1, \ldots$; first T_0 is applied repeatedly until convergence is obtained; the result is used as starting point for iterating with T_1, etc. In general, x_n is the result of starting with x_{n-1} and applying T_n repeatedly, until convergence is obtained, so that $x_n = T_n x_n$. Does the sequence x_n converge? It does if and only if the procedures T_n are so chosen that $T_{n+1}\, x_n - T_n\, x_n$ converges to zero. Schmidt establishes this fact and gives error bounds, after defining an appropriate concept of convergence which is general enough to be applicable to wide classes of problems yet specific enough to insure existence and uniqueness of the limit. The paper is of interest mainly to mathematicians, and the general tools which the author creates or shapes are as interesting as the specific results themselves.

F. L. Alt, USA

6464. Egerváry, E., On rank-diminishing operations and their applications to the solution of linear equations (in English), *ZAMP* **11,** 5, 376-386, Sept. 1960.

"A rank diminishing operation" of a very general type is established. Each application of this operation will reduce by one, the rank of a matrix, thus constituting a finite procedure when the matrices are finite. This is then used to give a general treatment of several different procedures for the solution of linear equations. Among these procedures are the elimination method of Gauss, recursive matrix inversion, the conjugate gradient method and general projection methods. The result of the paper is a very concise and beautiful treatment of several different methods in a unified way. At the basis of the work is the following lemma:

"By the subtraction of a dyadic $b\, c^*$ from a given matrix A the rank of A decreases just by one if and only if $b\, c^*$ has the form

$$\frac{A\, u\, v^*\, A}{v^*\, A\, u}$$

where u and v^* are arbitrary vectors subject only to the restriction $v^* A u \neq 0$." Using this lemma and starting from an arbitrary matrix A of rank r it can be decomposed into a sum of r dyadics by the following iterative procedure:

$$A_{k+1} = A_k - \frac{A_k u_{k+1} v_{k+1}^* A_k}{v_{k+1}^* A_k u_{k+1}}$$

and from this the different results follow.

B. Langefors, Sweden

6465. Hoffman, W., and Pavley, R., A method for the solution of the Nth best path problem, *J. Assn. Comput. Machy.* **6,** 4, 506–514, Oct. 1959.

Paper treats the problem of computing the Nth best path. If in a network there exists a unique path with a value such that exactly $N-1$ paths have smaller values, it is called "The Nth best path." The known construction of a minimum tree is used as the point of departure. It is pointed out that whereas the minimum tree is a convenient representation of the minimum paths it is useless for the computation of next-to-minimum paths.

A concept called "deviation" is introduced and used for the desired computation. If P is a path between two points 0 and D, a deviation is another path obtained from P by leaving P at some point and going along one single arc to a path in the minimum tree such that the result is a new path from 0 to D. An application to a street system is sketched to illustrate the usefulness of the procedure.

An indication as to how the method should be put on a computer is given.

B. Langefors, Sweden

6466. Ford, D. G., The fitting of damped sine-waves to data, Aero. Res. Lab. Melbourne, Austral. Note SM 264, 16 pp. + figs., Feb. 1960.

Book—6467. Bartee, T. C., Digital computer fundamentals, New York, McGraw-Hill Book Co., Inc., 1960, ix + 342 pp. $6.50.

This book is intended for the logical designer of computers, rather than the programmer or mathematician. The nine chapters deal respectively with Computer operations, Programming, Number systems, Basic logical circuits, Logical design, The arithmetic element, The memory element, Input-output devices, and The control element. Only a knowledge of the most elementary algebra is assumed, except in Chapter 4, which requires some knowledge of electronics. Fortunately the technical content of this chapter is not necessary for understanding the remainder of the book.

The style is elementary and readable, copiously illustrated by diagrams, and the explanations are clear, verging occasionally on the repetitious. Each chapter is followed by a list of suggested exercises. The hundred references cover the American literature through 1959, and also include half a dozen non-American works. To the best of the reviewer's knowledge, the entire field of digital computers in current production is well represented by the book, although some computer techniques still in the development stage are understandably omitted.

Author describes the various systems in use impartially, without expressing opinions on relative merits. A solitary lapse into unconscious prejudice occurs on page 29, in the statement that "it is both natural and fortunate that our number system is based on the number of digits we possess." Anyone with practical experience of converting decimal numbers into binary and vice versa surely needs no convincing of the inferiority of the decimal system compared with the octal system. The latter is not mentioned in the book, except in a reference title.

Reviewer believes there are small errors or slips on pages 48, 143, 201, 203, 225, 280, 281 and 334, but does not suggest that these appreciably detract from the value of this excellent textbook for the newcomer to this field.

A. H. Armstrong, England

6468. Smolarski, A. Z., and Trutwin, W., Analog computer for solving equations of stochastic media (in English), *Bull. Acad. Polonaise Sci., Ser. Sci. Tech.* **8,** 10, 569–573, 1960.

An analog computer is described consisting of a finite difference model of a transmission line the properties of which can be made to vary spatially and temporally. The computer is used to generate solutions of the equation

$$\partial w/\partial z = K(x,z)\,\partial^2 w/\partial x^2 + M(x,z)\,\partial w/\partial z + N(x,z)\,w$$

Techniques are given for supplying arbitrary boundary conditions. An example is given of the use of the analog to solve a problem of ground subsidence due to mining in the vicinity of a fault.

J. L. Lumley, USA

Analogies

(See also Revs. 6468, 6491, 6502, 6504, 6549, 6624)

6469. Duquenne, R., Study of airfoils under unsteady conditions with the help of electric analogies (in French), ONERA Publ. no. 98, 89 pp., 1960.

The unsteady, linearized, incompressible flow about a three-dimensional wing is investigated by aid of the analogy in an electrolytic tank. The electric potential corresponds to the velocity potential of the flow. Wing and wake are represented by a large number of electrodes separated by narrow isolating strips. Electric currents of intensities proportional to the normal perturbation velocity of the flow are led to the wing electrodes. The wake electrodes are brought at a potential which varies sinusoidally in flow direction. By an iterative procedure continuity of potentials at the trailing edge is obtained. The whole experiment is performed separately for the in-phase and the out-of-phase component.

A large number of results are given, viz. for two-dimensional wings, circular wings, rectangular wings of small aspect ratio and delta wings. Good agreement exists with theory. Special experiments have been performed for measuring the virtual inertia of oscillating wings in still air.

A. I. van de Vooren, Holland

6470. Stops, D. W., Simple means of computing two-dimensional steady-state heat flow in composite systems, *J. Sci. Instrum.* **38,** 6, 262–263, June 1961.

Representation of heat flow in bodies composed of two or more materials by means of conducting paper (Teledeltos) can be achieved by punching holes in the paper (to increase resistivity) or by pasting several layers together (to decrease resistivity).

A curve shows the relationship of resistivity and percentage area of holes.

Reviewer believes that this curve is not generally applicable because the resistance increase depends on shape and size of holes.

The example (Figure 2) is marred by apparent omission of some lines. The concept of increasing resistance by punching is not new [cf Kayan, *Trans. ASME* **67,** 713–716, 1945].

V. Paschkis, USA

Kinematics, Rigid Dynamics and Oscillations

(See also Revs. 6509, 6611, 6615, 6616, 6617, 6622, 6645, 6702, 6803, 6946, 6963, 7013)

Book—6471. Landau, L. D., and Lifshitz, E. M., Mechanics (Translated from the Russian edition by J. B. Sykes and J. S. Bell), New York, Pergamon Press; Reading, Mass., Addison-Wesley Publishing Co., Inc., 1960, vii + 165 pp. $7.50.

The first volume of the series "Course of theoretical physics" by the authors is now translated to English. For a short review and content of the book refer to the review of the Russian edition [AMR 13(1960), Rev. 3792]. O. Gurel, USA

Book—6472. Yeh, H., and Abrams, J. I., Principles of mechanics of solids and fluids, Vol. 1: Particle and rigid-body mechanics, New York, McGraw-Hill Book Co., Inc., 1960, xii + 359 pp. + appendices, $8.95.

Reviewer was pleased to find that the ground covered in Vol. 1 of this work is more extensive and interesting than the title suggests. The introduction to vector algebra in Chapters 1 and 3 is sound and well presented. Vectors are then used to deal with problems of statics, including rigid body and particle system problems in three dimensions. Vector derivatives are introduced in Chapter 6 where problems of the acceleration of a particle moving along a space curve are treated. Chapter 7 introduces rigid body kinematics, including some three-dimensional treatment. Chapter 8 deals with the dynamics of a single particle and under this heading treats harmonic motion, motion in a resisting medium, orbital motion, and equations of motion referred to a moving coordinate system. Chapter 9 treats vibrating systems: this includes forced and free vibration with and without damping, some brief remarks on nonlinearity and some reference to multi-freedom systems. Chapter 10 covers the dynamics of a system of particles; this includes something on rocket theory—the "variable mass" system—and something on the kinetic theory of gases. Chapter 11 treats the theory of the moments and products of inertia of a rigid body, the dynamics of rigid bodies being dealt with in the following chapter; this covers the general three-dimensional case. The final chapter deals with Lagrange's equations.

The book is clearly written and the worked examples have been well chosen to illustrate the physical meaning of the mathematical theory. The student should find the book refreshing. Mechanics is a subject which is liable to lead to frustration and boredom because it has to be studied for many years and yet involves very few principles; the book should help because of the width of its coverage and the originality of its presentation.

D. C. Johnson, England

Book—6473. Lamb, H., Statics, including hydrostatics and the elements of the theory of elasticity, 3rd. ed., New York, Cambridge University Press, 1960, xii + 357 pp. $3.75 (Paperbound)

Book—6474. Beyer, R., The kinematics and dynamics of linkages for the designer: Text and practice book for graphical analysis of two-dimensional linkages [Kinematischgetriebedynamisches Praktikum Lehr- und Ubungsbuch zur graphodynamischen Analyse ebener Getriebe], Berlin, Springer-Verlag, 1960, viii + 170 pp. DM 29.40.

The main aim of this book is to set forth the graphical treatment of the two so-called Wittenbauer's basic problems, that is to determine the motion of a given linkage subjected to given forces, or to determine the inertia forces in a given linkage whose motion is prescribed. Such a graphical treatment (which, for linkages of complex form, is usually preferable to the analytical one) is dealt with in this book, following the classical principles of mechanics already exposed by the author in his previous book: "Kinematische Getriebesynthese." The present book treats more complex cases, in view of practical applications in machine design.

Use is made of the method of reduced forces and masses, and of substitution masses, in calculating forces, inertia forces, energy, work made by forces.

After several simple examples, a concluding one, rather complex, is worked out, referring to a seven-element linkage. Special problems referring to plane motion of linkages are also dealt with (resulting inertia forces, according to Federhofer's method, dynamics of plane linkage with one or more grades of freedom, motion of the center of gravity of a linkage).

Determination of velocity variation in a periodic motion is also exposed, by means of the classical Wittenbauer's diagrams, and some simple problems are also solved, taking friction into account. Some final examples conclude the volume.

This book constitutes a clear and useful exposition of fundamentals in analysis of kinematics and dynamics of plane linkage. Together with traditional graphical procedures, some advantages of analytical methods could also have been, reviewer believes, more emphasized. R. Giovannozzi, Italy

Book—6475. Maxwell, R. L., Kinematics and dynamics of machinery, Englewood Cliffs, New Jersey, Prentice-Hall, Inc., 1960, xii + 477 pp. $9.75.

This junior and senior level (according to preface) text has a sound organizational concept, covering (as do other recent dynamics-of-machinery texts) kinematics (displacements, velocities, accelerations), basic mechanisms (linkages, gears, cams), and dynamics (inertia and friction forces) in one integrated book. Relative space and emphasis allocated to these topics appear proper.

Reviewer feels that book falls short of meeting author's aim "to write a book that the student can read" in several respects. Language is less concise and rigorous (occasionally even incorrect) than seems justified (such as in derivations of relative velocity concepts, attempts to define mass). Text is occasionally repetitious and devotes much valuable space to matters (e.g. rigid body dynamics derivations) adequately treated in available reference books, at the expense of important topics germane to a modern kinematics course (e.g. kinematic synthesis fundamentals, conjugate cams, equivalent link techniques for other than constant-radius-of-curvature direct-contact mechanisms). Several topics (e.g. Coriolis acceleration) are made to appear, in reviewer's opinion, unnecessarily complicated for junior students.

G. A. Nothmann, USA

6476. Jensen, P. W., Four-bar mechanisms, *Mach. Design* **33**, 13, 173–176, June 1961.

Use of a four-bar linkage is often limited by unfavorable angularity between members, requiring an excessive force to transmit a useful working force. For the same reason, pivot friction forces may make a mechanism lock up. This article presents a chart to use in linkage design to prevent these conditions.

C. E. Balleisen, USA

6477. Dijksman, E. A., Kinematic analysis of complex mechanisms in plane motion with one degree of freedom (in Dutch), *Ingenieur* **73**, 2, WI-WI4, Jan. 1961.

A determination of the positions and velocities of the instantaneous center of a complex plane mechanism leads to a new method for the analysis of the velocity and acceleration of any point of the mechanism. Determination of the acceleration of the instantaneous center leads further to a construction for finding the Ball point and other kinematic properties of the mechanism.

R. H. Macmillan, Wales

6478. Bogdan, R. C., and Pelecudi, C., Contributions to the kinematics of Chebychev's dyad (in English), *Rev. Mĕcan. Appl.* **5,** 2, 229–240, 1960.

The bars A_1B and A_2B are hinged in B, the transmission angle A_1BA_2 being ψ. If the position vectors OA_1 and OA_2 are given by their Fourier series then such a series is deduced for ψ.

O. Bottema, Holland

6479. Irimiciuc, N., Graphical solution of some spatial problems of finite bodies (in Romanian), *Bul. Inst. Politechnic Iasi* **6(10),** 1/2, 277–280, 1960.

6480. Spron, S. R., Use of a centrifuge for the precision measurement of accelerometer characteristics, *ASME Trans.* **83** B (*J. Engng. Industry*), 2, 202–206, May 1961.

A theoretically ideal accelerometer is perfectly linear. However, the vagueness of our knowledge of nature does not permit perfect linearity. A technique is developed for processing and interpreting accelerometer linearity data obtained on the author's (Amer. Bosch Arma Corp.) precision centrifuge.

Friction is kept to a minimum by reducing displacement of seismic mass to as small a value as absolutely possible; gradient effects of the centrifuge arm and close alignment of the gyro spin vector must be carefully considered. Thus, the basic output equation of the inertial accelerometer consisting of η terms of a Maclaurin series is modified to make the data suitable for centrifuge reduction. In turn this is accomplished by turning test accelerometer 180 degrees twice so as to reverse residual torque and apply negative g-inputs. Author calls this the "accelerometer bucking" error analysis scheme.

In the attempt to reapply g-levels to an accuracy of 1 in 10,000 on a centrifuge designed to 1 in 3000, an adjustment "to the same time base" was developed. This led to a centrifuge acceleration acceleration formula corrected for earth's rate, thus making possible measurement of the earth's rate with an accelerometer for the first time.

J. P. Vidosic, USA

6481. Rothman, H. L., and Chernoff, M., Effect of stability augmentation on frequency response of an aircraft in atmospheric turbulence, *J. Aerospace Sci.* **28,** 7, 587–588 (Readers' Forum), July 1961.

Very brief article shows advantage of stability augmentation in damping pitch oscillation of airplanes resulting from vertical atmospheric gusts. Equations consider two degrees of freedom (pitch acceleration and vertical acceleration), and curves, plotted as function of frequency of oscillation, illustrate reduction of dynamic motion of airplane as stability augmentation is increased. Effect is quite marked at low frequencies but not perceptible at high frequencies. Paper is of interest to those concerned with dynamics of airplanes.

C. W. Smith, USA

6482. Hull, E. H., Shaft whirling as influenced by stiffness asymmetry, *ASME Trans.* **83** B (*J. Engng. Industry*), 2, 219–226, May 1961.

An experimental investigation of phase-angle changes as well as the direction and frequency of whirl of shafts having stiffness asymmetry as the speed of rotation is varied. This asymmetry may be due to a flattened shaft (having two moments of inertia) in rigid bearings; or to a symmetrical shaft rotating in bearings having asymmetric stiffness. Physical explanation of test results is given to promote better understanding of these phenomena.

A. H. Church, USA

6483. Gutowski, R., On a certain method of integrating the equation of non-linear vibration of a system with one degree of freedom (in English), *Proc. of Vibration Problems* no. 5, 81–104, 1960.

This is a mathematical paper on the question whether an ordinary differential equation may be solved by quadratures.

O. Bottema, Holland

6484. Kozhevnikov, Ya. V., An analysis of the solutions of some variational problems in aeromechanics (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Aviats. Tekhn.* no. 2, 3–8, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7206.

Two variational problems of flight dynamics are examined: the problem of the optimum flight path in the vertical maneuvring of an aircraft; and the problem of the maximum length of flight along the trajectory. Introducing certain simplifications, in particular neglecting induced drag, the author arrives at a general solution the analysis of which leads to the conclusion that the steady-state condition is not a solution for both problems.

V. M. Ponomarev
Courtesy Referativnyi Zhurnal, USSR

6485. Litvin-Sedoi, M. Z., On dynamics of a gyroscope with two degrees of freedom (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 5, 72–78, Sept./Oct. 1959.

6486. Markhashov, L. M., On stability of gyroscopic motion in a Cardan suspension (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 5, 79–83, Sept./Oct. 1959.

6487. Pliss, V. A., Some problems in the theory of the global stability of motion [Nekotorye problemy teorii ustoichivosti dvizheniya v tselom], Leningrad, Izdatel'stvo Leningradskogo Universiteta, 1958, 182 pp. 8 r 40 k. (Paperbound)

The book investigates the global stability of the null solution of a system of three differential equations of the Aizerman type:

$$\dot{x} = f(x) + a_{12}y + a_{13}z; \quad \dot{y} = a_{21}x + a_{22}y + a_{23}z; \quad \dot{z} = a_{31}x + a_{32}y + a_{33}z. \quad [1]$$

If $a_{22} + a_{33} = 0$, system [1] is transformed into:

$$\dot{x} = y - f(x); \quad \dot{y} = z - x; \quad \dot{z} = -ax - bf(x). \quad [2]$$

If $a_{22} + a_{33} \neq 0$, system [1] is transformed into:

$$\dot{x} = y - f(x); \quad \dot{y} = z - cx - df(x); \quad \dot{z} = -ax - bf(x). \quad [3]$$

By replacing $f(x)$ by $[f(x)/x]x$ and treating $[f(x)/x]$ as a constant coefficient, generalized Hurwitz conditions are obtained for [2] and [3] which separate into 22 distinct cases, 7 for system [2] and 15 for system [3]. It is always required that $f(0) = 0$ and for $x \neq 0$, $[f(x)/x] > 0$. If $f(x)$ satisfies the generalized Hurwitz conditions, then for what values of the coefficients a, b, c and d is the null solution of system [2] or system [3] globally stable (stable in the whole)?

In order for the null solution of system [2] to be globally stable for any $f(x)$ satisfying the generalized Hurwitz conditions, it is necessary and sufficient that one of these three sets of conditions be satisfied: (I) $a < 0$, $b > 0$; (II) $a = 0$, $0 < b < 1$; (III) $a > 0$, $b < 0$, $a^2/(1-b)^3 + b \leq 0$. These account for 4 of the possible 7 cases and partially account for another case. The remaining three cases are dealt with in terms of sufficient conditions for the boundedness of solutions and for periodic motions.

In order for the null solution of system [3] to be globally stable for any $f(x)$ satisfying the generalized Hurwitz conditions, necessary and sufficient conditions, too lengthy to be reproduced here, are given which account for 6 cases and partially account for 4 of the 15 possible cases for this system. The remaining cases are dealt with in terms of sufficient conditions for the instability of the null solution and for the existence of periodic motions.

Throughout the book, use is made of Lyapunov's direct method of studying stability in addition to important new methods intro-

duced by the author. There are quite a few typographical errors and some of the theorem proofs are not clear but otherwise the book is clear and readable. There are 44 references listed, most of them in Russian. W. G. Vogt, USA

6488. Bogusz, W., Determination of stability regions of dynamic non-linear systems (in English), *Arch. Mech. Stos.* **11**, 6, 691–713, 1959.

For $\dot{x}_1 = f_1(x_1, x_2)$, $\dot{x}_2 = f_2(x_1, x_2)$, where f_i fulfill certain mathematical conditions, a clearly formulated stability criterion is proved by means of Lyapunov's theory. The different types of singular points are discussed and some examples added.
O. Bottema, Holland

6489. Leach, R. F., Nonmatrix formulation of an Eulerian angle vector transformation, *ARS J.* **31**, 6, 830–831 (Tech. Notes), June 1961.

Instrumentation and Automatic Control

(See also Revs. 6480, 6485, 6486, 6487, 6844, 6946, 6973)

6490. Mills, H. D., Smoothing in servo processes, *SIAM Rev.* **3**, 2, 131–139, Apr. 1961.

Paper discusses the synthesis of a discrete system satisfying (notation modified by reviewer)

$$e_{t+1} = e_t + n_t + c_{t-T_1}$$

for system variable e_t with servo corrections c_t (lagged T_1 periods) and system noise n_t, $\{n_t\}$ being white sequence with dispersion $\sigma_n^2 < \infty$, and means and dispersions of e_t, c_t have for $t \longrightarrow \infty$ finite limits $\bar{e}$, σ_e^2, $\bar{c}$, σ_c^2. The corrections are evolved in the form

$$c_{t+1} = S(e_j, n_j, c_j;\ j \leq t - T_2),$$

where S is an arbitrary function and T_2 information time delay.

Applications to inventory system and tracking system are outlined. To supplement references quoted in the paper, the reviewer suggests two articles by Prouza [Stroje na zpracování informací (Data Processing Machines), Symposium VI, 71–82, 1958, and *Apl. Mat.* **5**, 3, 196–201, 1960].

The problem under discussion is first to determine the lower limit of the ratio $k_e = \sigma_e/\sigma_n$ at a given magnitude of the ratio $k_c = \sigma_c/\sigma_n$ (smoothing capacity) and then to find a sequence $\{c_t\}$ for which minimum k_e is attained. The solution is carried out in detail for the special case of no delay ($T_1 = T_2 = 0$). Reviewer suggests to formulate author's Theorem 2 in a stronger form as uniqueness theorem of optimal linear servo class (7) which follows from basic properties of correlation coefficient.

In the general case, author combines both kinds of delays into total delay $T = T_1 + T_2$ and deduces inequality (8) for smoothing capacity. On the other hand, (7) is quoted as optimal servo class without further justification. Reviewer believes that in (8) term $1/2\sqrt{\ldots}$ should read $\sqrt{1/4\ldots}$, and moreover, in (7) e_t should be replaced by $e_{t+T_1} - \sum_{j=T_2}^{T_1-1} n_{t+j}$ and the important generalization of (14), viz. $c_{t+1} = (1-\alpha)^{T_2+1} c_{t-T_2} - \alpha \sum_{j=0}^{T_2} (1-\alpha)^j n_{t-T_2-j}$, following therefrom should be stated. In this manner corrections would be expressed in physically realizable form, i.e. as functions of type S mentioned above. F. Turek, Czechoslovakia

6491. Rjabow, B. A., Determination of dynamic parameters of control lines (in German), *Automatisierung: Z. Messen, Steuern, Regeln* **3**, 3, 125–130, Mar. 1960.

An experimental method is presented for determining the absolute values of unknown parameters of control elements. The theory of the method is derived on the assumption that the function of a control element is described by a linear differential equation with constant coefficients. The theoretical analysis is carried out for the case that the differential equation is of the second order of the type $M\ddot{x} + L\dot{x} + Kx = 0$. Two alternatives are considered:

(a) The control element is stable, the roots of the characteristic equation possess a real part smaller than zero.

(b) The control element is unstable.

For the case sub (a) the unknown parameters can be established by direct measurements from the response curve of the input function $f(t)$ for $t = 0$. The input function can have following form:

(1) $f(t) = a_0$ (2) $f(t) = b_0 t + b_1$ (3) $f(t) = d_0 t^2 + d_1 + d_2$

In case sub (b) the principle of the measuring method is that an element with unknown parameters is connected into a system containing elements with known parameters, i.e. in increasing the number of the degrees of freedom of the system under investigation. The known parameters of the system can be varied so that the system becomes stable and the response to the individual input function mentioned above equals zero for $t \to \infty$. Then the unknown parameters of the studied element can be calculated from formulas derived in the paper. The paper does not give a mathematical proof of the statement that in every case it is possible to stabilize the system by increasing the number of the degrees of freedom. A scheme is presented of connecting a control element into the measuring system. The necessary coordinates are picked up and converted to quantities necessary for the auxiliary elements with known parameters of the measuring system. The resultant coordinate acting upon the investigated element is again transformed to the required quantity in an energy transformer. An analog computer forming part of the measuring system with known and variable parameters is recommended as a suitable apparatus for investigating the unknown parameters.
F. Turek, Czechoslovakia

6492. Komarnitskaia, O. I., Application of the residue theory to transformation of automatic control systems equations to canonic variables, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **23**, 5, 1209–1217, 1959. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

Explicit formulas are given for the reduction of a system of n linear differential equations to the canonical form $\dot{z}_i = z_i \lambda_i$, $i = 1, \ldots, n$. M. Shinbrot, USA

6493. Reed, W. H., III, Hall, A. W., and Barker, L. E., Jr., Analog techniques for measuring the frequency response of linear physical systems excited by frequency-sweep inputs, NASA TN D-508, 59 pp., Oct. 1960.

Some data-reduction methods using general-purpose analog computing equipment and compatible testing techniques for determining the frequency response of linear physical systems are examined. The techniques considered may be classed as steady state or transient depending on the method of excitation. The relative merits of sinusoidal, slow sweep, and transient-type rapid-sweep forcing functions are discussed and applications are given that relate to dynamic-response tests of aeroelastic systems.
From authors' summary

6494. Popov, E. P., On evaluating the quality of nonlinear automatic systems with random interference, *Automation and Remote Control* **20**, 10, 1281–1287, June 1960. (Translation of

Avtomatika i Telemekanika **20**, 10, 1313-1319, Oct. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

The influence of random interference on the stability of nonlinear automatic control systems is investigated by application of a combination of the methods of statistical and harmonic linearization. This method of approach treats the signal at the input to the nonlinear element as the sum of a signal plus a random component. The effect of the nonlinear function on the random component is then approximated by the mean value and the dispersion giving the so-called statistical linearization of the nonlinearity.

An example is carried out in which the nonlinearity is due to saturation. The stability limits, in this case, turn out to be dependent on the level of the random interference.

L. H. Schindel, USA

6495. Kraichnan, R. H., Dynamics of nonlinear stochastic systems, AFOSR TN 60-717 (New York Univ., Inst. Math. Sci. Res. Rep. HT-7), 79 pp., July 1960.

Book—6496. Proceedings of a Conference on Theory and Application of Discrete Automatic Systems, [Teoriya i primenenie diskretnykh avtomaticheskikh sistem, Trudy Konferentsii] Moskva, Sept. 22-26, 1958; Moskva, Izdatel'stvo Akademii Nauk SSSR, 1960, 573 pp. 25 r 80 k.

Book is a collection of 48 papers presented at a conference in Moscow, September 22 to 26, 1958. Professor Ya Tsypkin, outstanding Soviet expert on discontinuous control and holder of the Order of Lenin, served as chief editor for this volume. An introduction outlines the major theoretical and practical problems of discrete automatic control systems which are of current interest. The papers are grouped into four categories. These are: optimal relay systems, impulse systems, digital systems, and extremal (self-optimizing) systems. Extensive use is made of modern mathematical techniques throughout the book, drawing from the calculus of variations, abstract algebra and other areas as needed.

In the papers on applications generous use is made of transistors, solid-state diodes and other up-to-date physical components. The papers in the first category are concerned with the determination of the optimum response of relay systems and the introduction of forward and feedback paths for achieving this response. Generous use is made of the phase plane to clarify the results. By "optimum response" is meant the return to equilibrium in minimum time after a disturbance, or the minimization of some other quantity than the duration of the transient. The papers in the second group are concerned with the theory of linear impulse systems with variable parameters, compensation networks for discrete systems, various modulation techniques for changing continuous to discrete signals, the problem of auto-oscillations of intermittent control systems, the use of extra intermittent signals, the design of discrete filters, and the discrete control of systems from photoelectric indicators. Among the topics treated in the third section are the discrete control of thermoelectric generating systems, program control of radio centers, the use of Z-transforms in the design of digital systems, means for digitally performing mathematical operations such as multiplication, means for transforming angular position to digital information, the use of cathode ray tubes in treating digital signals, computing machines for analyzing relay systems and means for reducing logical equations. The fourth and last set of papers is concerned with self-optimizing nonlinear systems, the use of automatic relay systems for locating the maximum or minimum value of some variable, the use of frequency response techniques in the computation of relay-impulse systems, the design of a self-optimizing pneumatic controller, the effect of noise on self-optimizing controls, various means for automatically searching the minimum or maximum value of a function, and designs of electronic self-optimizing controls.

In the opinion of the reviewer this book presents an excellent survey of the important areas of discrete automatic control theory. Although he found no radically new innovations in the papers no major topics in the field were overlooked. The reviewer feels that the reader will find in the present volume an excellent picture of the state of Russian efforts, which on the whole are mature and practical.

R. Oldenburger, USA

6497. Flugge-Lotz, Irmgard, and Ishikawa, T., Investigation of third-order contactor control systems with two complex poles without zeros, NASA TN D-428, 69 pp., June 1960.

Paper reports an investigation of third-order systems under contactor control. The transfer function of the uncontrolled system has one real and two conjugated complex poles and may have zeros. Systems with zeros are discussed only briefly. Cases with positive real parts of the complex poles are included. The switching function depends on error and error derivatives, the error being the difference between the input and output of the system. For an initial error (step input) the coefficient k_1 and k_2 of linear switching function $F = e + k_1 e' + k_2 e''$ can be chosen in such way that the step height can be reached in minimum time without chatter.

The dependence of the coefficient k_1 and k_2 on step height for fixed system parameters has been studied theoretically and with the help of an analog computer. The dependence of k_1 and k_2 on the system parameters has been considered. It is presented that unstable systems can be satisfactorily controlled. The response of controlled systems to time-varying input has been studied. In the last section of the paper, first results of the analysis of systems with zeros in the transfer function are described.

From authors' summary by Z. Rezny, Czechoslovakia

6498. Desoer, C. A., and Wing, J., Minimal time regulator problems for linear sampled-data systems (general theory), AFCRL 149, AFOSR 424 (Univ. Calif., Inst. Engng. Res. Series 60, Issue no. 346), 37 pp., Feb. 1961.

6499. Desoer, C. A., Pontriagin's maximum principle and the principle of optimality, *J. Franklin Inst.* **271**, 5, 361-367, May 1961.

This paper gives a simple, direct and thus elegant way of deriving Pontriagin's maximum principle; this principle rules the optimum control of a dynamical system described by an n-vector equation: $\dot{x} = f(x, u, t)$ which minimizes a certain time integral $\int_{t_0}^{t} f_0[x(\tau), u(\tau), \tau]\, d\tau$ of a function of the state x and of the control signal u, the latter being restricted to remain in a specified closed and bounded region Ω.

The derivation makes use of what the author calls the principle of optimality, which in fact is the expression of a necessary condition satisfied by the minimum value $\Gamma(x, x_0)$ of the integral between two states, assuming that the optimal trajectory exists. Further assumptions on the continuity of first derivatives lead straight to Pontriagin's principle, which says that the optimal control maximizes the scalar product: $|(f_0, f_1, \ldots f_n), (-1, \partial\Gamma/\partial x_1, \ldots \partial\Gamma/\partial x_n)|_{u=u_0}$, (for $u \in \Omega$); furthermore this maximum is zero (orthogonality). Main interest of this principle is to point, in some cases, to significant properties of the considered control problem ("bang bang" solutions, for ex.)

The present derivation shows also that the maximum principle, valid at each point of the optimal path, does not depend on the terminal conditions imposed on the optimal trajectory.

F. Buckens, Belgium

6500. Grishchuk, V. P., and Samoilenko, Yu. I., Approximate methods of selection of optimal tuning of systems of intermittent

control (in Russian), Avtomatizatsiya i Priborostroenie, Gosplan UkrSSR, Kiev, Inst. Avtomatiki no. 1, 80–87, 1959.

6501. Klumpp, M., The dynamic Cardan error of the measuring compass (in German), *Ing.-Arch.* **30**, 3, 153–159, Mar. 1961.

Calculate the drift error of a gyrocompass, fixed to the earth, caused by a combination of vibration and the existence of a (small) product of inertia of the inner gimbal ring about two perpendicular horizontal axes. The result shows a small rectified azimuth error proportional to the square of the intensity of the free nutational vibration and to the first power of the gimbal product of inertia. J. P. Den Hartog, USA

6502. Eggleston, J. M., and Dunning, R. S., Analytical evaluation of a method of midcourse guidance for rendezvous with earth satellites, NASA TN D-883, 61 pp., June 1961.

A digital-computer simulation was made of the midcourse (or ascent) phase of a rendezvous between a ferry vehicle and a space station. The simulation involved a closed-loop guidance system in which both the relative position and relative velocity between ferry and station are measured (by simulated radar) and the relative-velocity corrections required to null the miss distance computed and applied. The results are used to study the effectiveness of the guidance equations and the effects of errors in launch conditions and errors in the navigation (radar) data. Trajectories are presented for rendezvous with a space station in a circular orbit and in an elliptic orbit.

From authors' summary

Book—6503. Zalmanzon, L. A., and Cherkasov, B. A., Control of gas-turbine and ramjet engines, NASA TT F-41, 259 pp., July 1961.

This book deals with the principles of control of aviation gas turbine and ramjet engines. Attention is concentrated on describing the physical bases of the processes of engine control and an exposition of the methods of experimental study and design of control apparatus. A series of examples brings out the close connection between the operation of the elements in the control loop and the fuel supply system of the engines. The characteristics of the several elements of the fuel apparatus are given. The book is written as a textbook for students in Aviation Institutes, but may also be useful for workers specializing in the field of aviation engines. From authors' preface

Book—6504. Kolosov, S. P., Kolpakova, N. P., Sodolov, N. I., Ter-Akopov, A. K., Tishchenko, N. M., and Udalov, N. P., Guidance for the design of automatic elements and systems [Rukovodstvo po proektirovaniyu elementov i sistem avtomatiki/, Moskva, Oborongiz, 1959, 201 pp. 7 r 10 k.

This textbook, by members of the Moscow Order of Lenin Aviation Institute Sergo Ordjonikidze for course and thesis design projects, is written from the viewpoint of the electrical engineer. The first six chapters are devoted to design problems in connection with magnets, photoelectric relays, contactless magnetic relays involving diodes and electromagnetic components, thermobimetal-strip relays, magnetic amplifiers, and solenoids. The remaining two chapters are devoted to the factors involved in the design of automatic controls and the use of models in investigations of the dynamics of automatic control systems. The book is full of algebraic formulas needed for the design of the electrical components mentioned above. The background for these formulas is often missing, but enough is given to enable a designer to construct a device to meet given specifications. The section on automatic control covers block diagrams, transfer functions, the use of convolution integrals, and weighting functions for expressing system response. The aircraft autopilot is treated as an application.

In the opinion of the reviewer this book is a valuable introduction to the study of the design of electromagnetic components and their use in automatic control systems.

R. Oldenburger, USA

Book—6505. Katys, G. P., Elements of systems of automatic control of nonstationary flow [Elementy sistem avtomaticheskogo kontrolya nestatsionarnykh potokov], Moskva, Izdatel'stvo Akad. Nauk SSSR, 1959, 210 pp. 8 r 40 k.

In the reviewer's opinion the book is no doubt intended for those readers with an engineering background who wish to become conversant with the simpler engineering aspects of hydraulic control. The bulk of the book is expository, although a few hydraulic components are discussed. Problems are lacking and the general level of the analysis appears to be very elementary when compared with that which was applied to similar problems in papers emanating from the MIT staff approximately some eight to twelve years ago. Unfortunately the title leads one to expect more than the book has to offer. If it were presented as a semi-technical introduction to hydraulic control, it would then be satisfactory, since the discussion is clear.

W. C. Orthwein, USA

6506. Harned, J. L., Sudhindranath, P., Miller, K. M., and Roddy, R. J., Transfer-function derivation and verification for a toric variable-speed drive, *ASME Trans.* **83** D (*J. Basic Engng.*), 2, 265–274, June 1961.

Basic relationships that control the dynamic performance of toric variable-speed drives are studied. These basic toric relationships are then utilized to derive seven linear differential equations that describe a commercial model of a toric transmission. Experimental verification of these equations is made to support the theoretical work. By means of a numerical evaluation of the transfer functions, a simplified interpretation is made to show the relationships between transmission parameters and dynamic performance. From authors' summary

6507. Selsted, W. T., and Dinsmore, J. A., A mechanical braking system with feedback and servo characteristics, *Prod. Engng.* **32**, 27, 41–42, July 1961.

Elasticity

(See also Revs. 6449, 6473, 6529, 6531, 6546, 6547, 6548, 6551, 6568, 6571, 6575, 6577, 6578, 6580, 6601, 6638, 6658, 6661, 6840, 7001)

Book—6508. Pasler, M., Mechanics of elastic bodies [Mechanik Deformierbarer Korper (Sammlung Göschen, Band 1189/1189a)], Berlin, Walter De Gruyter & Co., 1960, 199 pp. (Paperbound)

This book forms part of the well-known Goeschen series of review books. Title is somewhat unusual in that "deformable bodies" are defined to include not only solid bodies, but also liquids and gases. After brief introduction on vector and tensor analysis and wave equation (18 pages) Part B (61 pages) is devoted to deformable solid bodies and Part C (107 pages) to liquids and gases.

Statics of elastic solid bodies are treated by means of vector and tensor analysis. Usual results given in many textbooks (equations of equilibrium and compatibility, stress-strain relations, Airy stress function, energy principles) are derived. Equally brief chapter on dynamics deals with equations of motion and their general solution, elastic waves in infinite bodies and vibrating strings. Latter chapter is only application of general theory in Part B.

Part C is devoted mainly to ideal fluids and gives brief introduction to various well-known subjects of hydrodynamics and gasdynamics such as: equations of Euler and Bernoulli, velocity potential, circulation, vorticity, etc. Last chapter on viscous fluids deals with Navier-Stoker equations and some applications and brief remarks on turbulence.

F. J. Plantema and H. Bergh, Holland

Book—6509. Muller, W., Theory of elastic deformations [Theorie der Elastischen Verformung], Leipzig, Geest & Portig K.-G., 1959, xi + 327 pp. DM 31.50.

The contents of this tract serve as an introduction into the realm of more advanced mechanics dealing with deformable elastic bodies in an integrated manner. It consists of two parts. The first part contains sections on vectors, dyadics (second rank tensors), strain dyadics, stress dyadics, relations between stress and strain dyadics, the strain energy, general principles of work and energy, basic minimal principles of calculus of variations, Castigliano's, Menabrea's and Maxwell's principles and curvilinear coordinates.

The second part deals with a representative selection of topics in elasto-mechanics such as torsion of noncircular prismatic members, flexure of thin circular, elliptic, triangular and rectangular plates subjected to various typical cases of load, such as uniform hydrostatic, concentric and eccentric concentrated loads, and the so-called flat slab structures. The thin shells of rotation are subjected to various common cases of loading. The bending theory of rotational thin shells is treated for spherical thin shells by means of the classic Reissner-Meissner theory and Geckeler's approximate solution. The thin conical shell is also studied for its transverse bending by means of the general Reissner-Meissner theory. Stability of columns under various boundary conditions and loads is treated by means of energy and geometric methods.

Buckling of cylindrical thin shells, also of rectangular, circular and triangular plates, is studied. The section on vibration problems deals with the vibration of strings, membranes of various configuration, beams and thin plates.

The section on wave phenonena deals with the plane compression and shear waves, Maxwell's equations; spherical, cylindrical and surface waves; waves propagated in long plates of finite thickness and in cylinders.

The first part of this book deserves a more detailed scrutiny since it employes a mathematical approach to the basic theory which, in the reviewer's opinion, is far superior to anything he has seen in textbooks of this kind. The mathematical description of the basic concepts in engineering mechanics has been formulated according to the Gibbsian concept of directed quantities (tensors according to Grossmann's definition): The degenerate directed quantity (of zero order) is a scalar, the first-order directed quantity is the basic engineering vector concept and the next higher order directed quantity to vectors is the dyadic. Gibbs, who possessed great engineering powers, originated his vector and dyadic analysis in order to deal with the most prevalent engineering concepts in a symbolic manner, yet maintaining a close contact with the physical analogy. Unfortunately for engineering, the success of Einstein's relativity has brought on a fashion of the so-called tensor analysis, which is a cabalistic method in the extreme. It is now being applied to all sorts of engineering problems regardless of whether the nature of such problems warrants the application of this abstract and intricate tool in mathematics. Gibbs' dyadic analysis on the other hand avoids this unnecessary abstraction and keeps its feet on the ground by never losing sight of the vector (provided that the vector constitutes the most fundamental and physically conceivable concept in mechanics) since it enters into a dyadic in a "natural" way. While Gibbs' great contribution has been all but neglected by engineers in his own country, its great pedagogical power in engineering mechanics has been amply demonstrated by many engineers in Europe, such as Professor Müller of Germany and Professor Lur'e of Russia.

The investigations on the stress and strain dyadics are without peer as far as the physical appreciation of the second-order "vector" (directed) nature of such concepts is concerned, at least for engineers. It is shown that the stress dyadic has the form

$$\theta = \sigma_x \overline{ii} + \sigma_y \overline{jj} + \sigma_z \overline{kk} + \tau_{yz} \overline{jk} + \tau_{zy} \overline{kj} + \tau_{zx} \overline{ik} + \tau_{xy} \overline{ij} + \tau_{yx} \overline{ji},$$

in which any component has to be specified by a pair of directed quantities, or independent unit vectors, such as i j, etc., in contrast to a single unit vector in the case of vectors. The symmetry of stress dyadics and strain dyadics is proved; the principal axes and the invariants derived in a precise manner. The vectorial treatment of the state of strain is the clearest physical representation available, culminating in the strain dyadic $\Phi = 1/2(\bar{\nabla}\bar{v} + \bar{v}\bar{\nabla})$, where v designates the displacement vector. The component of a dyadic in the direction of a unit vector e is $\Phi_{ee} = \bar{e} \cdot \Phi \cdot \bar{e}$ (in analogy with vectors: $v_e = \bar{e} \cdot \bar{v}$). The strain and stress surfaces are introduced and Mohr's and Huber's strength theories discussed at some length. All possible expressions are developed for the strain energy quantity. In analogy to the work of a force expression $\int \bar{F} \cdot d\bar{r}$ the strain energy is given by the cryptic $U = \int \theta : \sigma \Phi dv$. Some basic relations are developed by means of equations of motion instead of the static equilibrium equations—a modern approach quite widely used in Europe. Hamilton's principle is also treated for elasto-kinetic problems.

Generalized curvilinear coordinates are treated in a general vectorial manner. The cylindrical, spherical, polar, bipolar, elliptic-cylindrical and ellipsoidal coordinates are specifically deduced from the generalized coordinates in the most easily understandable and cryptic way the reviewer has seen in a textbook of this type. The equilibrium equations for thin shells of rotation are derived by means of minimal principles and general curvilinear coordinates.

The author has been successful in demonstating the great descriptive power of Gibbs' dyadics in treating the *engineering theory* of tensors of the second rank. (A more penetrating and broader application of dyadics to elasticity is given in the excellent monograph by Lurʹé "Prostranstvevvye Zadachi Teorii Uprugosti" 1955 [AMR **9**(1956), Rev. 2850] that should be required reading for any writer on elasticity.)

Author of this work possesses a great gift in being able to express ideas in a few words for which many writers need long discussions. The author's Miniature "Dynamik," Sammlung Göschen nos. 902, 903, Walter de Gruyter, 1952 [AMR **6**(1953), Rev. 1164], an excellent short text on dynamics including the inertia dyadic theory, stands as a testimonial to his ability in conciseness and pedagogical powers. The reviewer recalls few textbooks which have afforded such an easy reading of this difficult subject.

On the debit side reviewer finds too few references mentioned in the book and there are a few occasional misprints. Reviewer also finds a dearth of historical references, and a few which are given are not correct; the most outstanding error is on page 73 where the priority of the reciprocal relation in elasticity is accorded to Betti instead of Maxwell.

Author could have simplified his dyadic presentation by adopting $\bar{e}_x = \bar{i}$, $\bar{e}_y = \bar{j}$, $\bar{e}_z = \bar{k}$, and also the very descriptive bold face $\overline{\mathbf{D}}$, for dyadics $\overline{\mathbf{D}} = \sum_i \sum_j D_{ij} \bar{e}_i \bar{e}_j$ $(\bar{i}, j = x, y, z)$. Expressions like $U(\varepsilon + \delta\varepsilon, \gamma + \delta\gamma) = U(\varepsilon, \gamma) + \Sigma(\partial U/\partial\varepsilon)\delta\varepsilon + \Sigma(\partial U/\partial\gamma)\delta\gamma + (1/2)\,[\partial^2 U/\partial\varepsilon_x^2)\,(\delta\varepsilon_x)^2 + \ldots]$ could have been put in a form

$$U(\varepsilon + \delta\varepsilon) = U(\varepsilon_{ij}) + \sum_{i,j} (\partial U/\partial\varepsilon_{ij})\delta\varepsilon_{ij} + (1/2) \sum\sum_{i,j,k,l} (\partial^2 U/\partial\varepsilon_{ij}\partial\varepsilon_{kl})\, \delta\varepsilon_{ij}\delta\varepsilon_{kl} \; (i,j,k,l, = x,y,z).$$

The strain energy quantity would appear in the descriptive form $U = \int \bar{\sigma} : \delta \bar{\varepsilon} dv$.

This book constitutes an integrated introductory course on elasto-mechanics and is recommended reading to anybody interested in this subject matter, for the author knows how to make study a pleasant experience. G. Oravas, Canada

Book—6510. Teodorescu, P. P., Plane problems in the theory of elasticity, Vol. 1 **[Probleme plane in teoria elasticitatii],** Bucharest, Editura Academiei R. P. R., 1961, 996 pp.

Book represents an intensive treatment of the plane problem, done with all the mathematical accuracy.

The problems are successively presented; the greatest importance is given to the static problem where the classification criterion is the boundary shape and the most convenient system of coordinates.

The introductory part (Chapter I) contains general considerations on the theory of elasticity (object, basic assumptions, elastic equilibrium, strains, Hooke's law, fundamental problems, mechanical work, existence and uniqueness theorems, simply and multi-connected bodies, Saint-Venant's principle).

Chapter II examines the plane stress and strain state. Chapter III presents various aspects of the theory by using Cartesian coordinates (the plane variation of stresses and strains, solution in stresses and displacements of the plane problem, symmetry and antisymmetry properties, etc.).

After a brief examination of the calculus approximation of the plane problem (Chapter IV), author presents the calculation methods used in this domain (Chapter V). Particular integrals of the biharmonic equations are presented as well as general calculation methods (direct, indirect and semi-indirect methods, elementary methods, variational methods, Fourier representations, operational methods, method of complex variable functions, finite difference method, approximation of boundary conditions by points, analogy with plane plates and experimental methods).

The second part, which is the most extended, deals with the calculation of deep beams with rectangular boundary. The ordinary beam, the plane, the half-plane, the quarter of plane, the elastic strip and half-strip, and the deep beam are treated from the viewpoint of form and dimensions. The simple support, the continuity on supports, the clamping and the beams on elastic medium are studied from the viewpoint of the support.

As calculation methods, author uses especially solutions by polynomials and developments into series, without neglecting other procedures.

The symmetry and antisymmetry properties are successfully used, thus substantially simplifying the calculations whenever possible.

The theoretical treatment is illustrated by numerous numerical examples and diagrams. Particular attention is paid to an examination of the validity of formulas in the strength of materials as compared to more accurate solutions in the theory of elasticity.

The 696 pages of text are completed by 300 more pages containing appendices and original tables and diagrams which facilitate the numerical applications.

Based on a large number of references (over 300 authors are cited) and on the rich original activity of the author, this monograph represents a particularly valuable contribution in the field.
M. Soare, Roumania

6511. Dundurs, J., and Hetenyi, M., The elastic plane with a circular insert, loaded by a radial force, *ASME Trans.* **83** E (*J. Appl. Mech.*), 1, 103–111, Mar. 1961.

Different elastic properties are assumed for insert and plate and perfect bond between materials. Plane-strain and plane-stress solutions are obtained, within classical theory of elasticity, using the Muskhelishvili method of complex function for the determination of Airy stress functions for the two regions. The stress functions satisfy conditions of continuity at interface between regions, force singularity, and stress attenuation at infinity. They are deduced through a judicious selection of the Muskhelishvili complex functions guided by known solutions of related problems which are special cases of present one, namely, two joined half planes, an empty hole and/or force at interface between insert and plate.

Explicit formulas are given for components of stress in cartesian coordinates, and also in polar coordinates at circumference of interface. Limiting cases are derived and checked against known solutions and a numerical example is presented in form of stress distribution curves. D. C. Gazis, USA

6512. Karas, K., Calculation of shrinkage stresses in turbine disks with a consideration of the rim of the blade (in German), *Forsch. Geb. Ing-wes.* **26,** 6, 191–197, 1960.

A refinement on the usual calculation of a spinning turbine disk of constant thickness, by the introduction of an external ring of finite cross section, holding the roots of the turbine blades. The formulas are worked in detail and numerical examples are given.
J. P. Den Hartog, USA

6513. Ferrarese, G., The characterization of total deformation of a tube with multiply-connected cross section and a new form of the compatibility condition for finite displacement (in Italian), *R. C. Mat. Appl. Univ. Roma* **18,** 3/4, 267–282, July/Dec. 1959.

Author considers general multiply-connected tubular region. Assuming that all cross sections remain perpendicular to the centroidal axis l of the tube (the centroidal axis of the multiply-connected tube is defined to be the centroidal axis of the solid region bounded by the outermost surface of the tube), the author shows that the shearing strain and the cubical dilatation are linear functions of the rectangular cartesian coordinates of a point relative to the centroidal axis. The compatibility condition for finite displacement is expressed in terms of the quadratic of the strain ($\omega = 1 + 2\varepsilon$, where ε denotes strain). The relationship between the centroidal axis l and the deformation is discussed. A system of total differentials from which the systematic deduction of the local displacement may be obtained is presented. An analogy between the tubular solid and the problem of motion of a rigid body with fixed point is indicated. A. P. Boresi, USA

6514. Bernstein, B., Hypo-elasticity and elasticity, *Arch. Rational Mech. Anal.* **6,** 2, 89–104, Oct. 1960.

Author discusses question whether a given hypoelastic material is elastic. Additional stipulations are necessary, in addition to the equations of hypoelasticity, to define a hypoelastic material in general. The most important result of paper is theorem IV: "If for a given hypoelastic material the work done by the stresses is non-negative for all (kinematically possible) motions for which the initial and final configurations are the same, then this material is elastic in the sense of Green."
W. T. Koiter, Holland

6515. Rao, K., Gravitational stresses on deep tunnels, Proceedings of the Fifth Congress on Theoretical and Applied Mechanics, Univ. of Roorkee, Roorkee, India, Dec. 23–26, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., C. 103–C. 110.

Using Muskhelishvili's complex variable methods author considers plane strain problem of stresses around deep tunnels, of general epitrochoid cross section, due to gravity.
A. E. Green, England

6516. Lakshminarayana, G., Finite strain in rotating cylinders, Proceedings of the Fifth Congress on Theoretical and Applied Mechanics, Univ. of Roorkee, Roorkee, India, Dec. 23–26, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., C. 17–C.26.

Using a special linear stress-strain relation author obtains an approximate solution for problems of rotating compressible hollow, solid and composite circular cylinders.

A. E. Green, England

6517. Singh, A., Axisymmetrical thermal stresses in transversely isotropic bodies (in English), *Arch. Mech. Stos.* **12**, 3, 287–304, 1960.

This paper deals with a stress function approach for the solution of the axisymmetric steady-state thermoelastic problem for transversely isotropic material, in the presence of body forces. It is assumed that the axis of elastic symmetry is coincident with the z-axis and the elastic and thermal properties in the directions of the r and θ-axis are the same but are different in the z-direction.

The formulation of the problem shows that all components of the stress tensor and of the displacement vector are expressed in terms of either of two pairs of stress functions and certain constants which satisfy quadratic equations involving elastic constants. As an illustration, the problem of stress distribution within a transversely isotropic semispace, is solved using Hankel transform techniques. The boundary plane of the semispace is subjected to a constant temperature over a circular area, the external of the circle being thermally insulated. The integrals occurring in the expressions for stresses have been completely evaluated and numerical work performed considering magnesium as the anistropic material. The numerical results for isotropy are also presented for comparison. This comparison shows that anistropy increases the stresses, in this case by less than ten per cent. The author points out, however, that magnesium is very nearly an isotropic material, and that for materials with greater anistropy the difference between the two calculations would increase.

D. W. Breuer, USA

6518. Derski, W., On transient thermal stresses in an infinite thin plate (in English), *Bull. Acad. Polonaise Sci., Ser. Sci. Tech.* **8**, 9, 503–507, 1960.

Paper considers the problem of a point heat source of the Dirac type applied to a very thin plate which is infinite in extent. Cylindrical coordinates are used with the origin chosen at the location of the point heat source. The heat conduction and the displacement equation are written in terms of the independent variables radius and time. The heat-conduction equation neglects the effects of displacement coupling and has an explicit solution. The displacement equation includes the inertia terms and the temperature term. A solution to the displacement equation is found by means of Laplace and Hankel transforms. The integration constants are evaluated by the application of initial and boundary conditions. From the displacement equation the equations for the radial and tangential stress are obtained. The radial stress and the radial displacement are plotted against time for a particular radius. The graph for the stress shows an infinite discontinuous jump in the stress when the stress wave passes over the particular radius. The displacement graph exhibits a discontinuous slope at this same point. Other investigators [Boley, B. A. and J. H. Weiner, "Theory of thermal stresses," John Wiley & Sons, Inc., AMR **14** (1961), Rev. 1790; Nariboli, G. A., "Spherically symmetric thermal shock in a medium with thermal and elastic deformations coupled," *Quart. J. Mech. Appl. Math.* **14**, Part 1, 1961] have pointed out that the jump in the stress magnitude is decreased if the coupled temperature conduction equation is solved.

D. W. Breuer, USA

6519. Reissner, **E., On some variational theorems in elasticity,** Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishivili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 370–381.

In several previous publications [AMR **4**(1951), Rev. 2381; **6**(1953), Rev. 1847; **7**(1954), Rev. 1042] author has studied a general variational theorem in elasticity for which the equilibrium equations and the stress displacement relations appear as Euler differential equations and the boundary conditions are natural Euler conditions. The classical minimum principle for displacements and the maximum principle for stresses have been shown as consequence of the Reissner variational theorem which also may be used for approximate solution of some boundary-value problems.

The present paper extends former results to a larger class of questions. The more general conception enables the author to generalize the classical formulation of the extremum principles for stresses and for displacements. The main value of this important paper lies in that it brings a common starting point for generalizing the classical extremum principles of elasticity.

Reading of the paper presupposes an adequate routine in higher mathematics and analytical mechanics. Full understanding will be made easier by beginning the study with the above-cited papers of the author.

V. Vodicka, Czechoslovakia

6520. Chakravorti, A., Center of flexure of an aeolotropic beam having a curtate section (in English), *Atti Accad. Sci., Torino* **95**, 131–144, 1960/61.

A prismatic cantilever beam whose cross section is a sector of a thick cylinder with axis OZ carries a point load directed normally to the plane of symmetry of the beam. The elastic constants of the beam material have cylindrical symmetry about OZ. The distance of the load from OZ for which the mean twist over the beam cross section is zero is determined, in series form, for three different sets of restrictions on the aeolotropy.

J. H. Percy, USA

6521. Brandt, H. E., On a generalized solution to a torsion problem in linear elasticity, *J. Aerospace Sci.* **28**, 5, 422–424 (Readers' Forum), May 1961.

An approximate solution is presented of the problem of torsion of bar with regular polygonal cross section. The solution is made by Galerkin's method using the first approximation and is a generalization of Stanšić's paper [*J. Aerospace Sci.* **27**, 8, 631–633, Aug. 1960; AMR **14**(1961), Rev. 1238]. A more general solution of the problem is given e.g. by W. Zapalowicz [*Arch. Mech. Stosowanej* **11**, 5, 559–594, 1959; AMR **13**(1960), Rev. 3296].

A. Hanuska, Czechoslovakia

6522. Das, S. C., Bars reinforced by hyperboloid type notches under torsion, Proceedings of the Fifth Congress on Theoretical and Applied Mechanics, Univ. of Roorkee, Roorkee, India, Dec. 23–26, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., C.111–114.

The well-known Neuber's solution for the so-called deep external notch in a twisted round bar, i.e., for the elastic medium enclosed by a hyperboloid of one sheet, is extended by the author to the case in which the hyperboloid surface forms the boundary between two different elastic materials.

R. Schmidt, USA

6523. Deresiewicz, H., A note on second-order Hertz contact, *ASME Trans.* **83** E (*J. Appl. Mech.*), 1, 141–142 (Brief Notes), Mar. 1961.

Paper considers elastic contact of two solids of revolution whose superficial points at distance r from the axis of contact are apart by $z = Ar^2 + Br^4$. Cattaneo has given the solution of this problem, for any A and B, in the form of a set of algebraic equations which

can be solved numerically to determine the pressure distribution, normal approach and area of contact [AMR 1(1948), Rev. 787)]. Author assumes $8a^2 \mid B \mid \ll 5A$ and solves approximately the Cattaneo equations, obtaining small corrections to the Hertz theory which corresponds to $B = 0$. He gives expressions for the equilibrium pressure, normal approach and contact area and also for the case of impact, the maxima of these quantities and the duration of impact. D. C. Gazis, USA

6524. Truesdell, C., Stages in the development of the concept of stress, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 556–564.

In an interesting, nonmathematical manner, the author traces the development of the concept of internal stress through the various special applications from the time of Archimedes to the general formulation by Cauchy. E. H. Dill, USA

Viscoelasticity

(See also Revs. 6514, 6625, 6707)

6525. Distefano, J. N., Asymptotic behavior of viscoelastic bodies having hereditary characteristics (in Italian), *Atti Accad. Sci., Torino* **95**, 69–76, 1960/61.

Author assumes the Vito Volterra type hereditary relation between stress and strain. He further shows that as time $t \longrightarrow \infty$ the integral-type relation may be replaced by Hookean stress-strain law where Young's modulus E is now replaced by a modulus E^* so that

$$E^* = E/(1 + E\gamma).$$

The Poisson ratio is still ν, the same as in classical elasticity for isotropic bodies, and γ is properly defined.

Some brief mention is made of application of the theory to instability problems. W. H. Hoppmann, II, USA

6526. Hult, J., Oil canning problems in creep: Part 1 (in English), Instit. Hallfasthetslara, KTH Publ. no. 130, 18 pp. + figs., 1960.

Stability of transversely loaded nearly flat structures on hinged supports is studied. It is shown that for material subject to creep a sudden jump in the equilibrium configuration can occur. Numercial results are presented for a two-bar system using a linear visco elastic creep law. It is shown that a jump can occur either due to compression of the bars or due to buckling of a bar. An equation is derived for the time at which the jump occurs. An additional analysis is given where the bars are assumed to be slightly curved in a sinusoidal shape when unloaded. This analysis shows that an initial mid-span deflection markedly reduces the "lifetime" prior to a jump. Finally an analysis is given for a curved beam in which it is shown that the presence of harmonics in the deflection curve significantly reduces the "lifetime" of slender beams. S. Levy, USA

6527. Aleksandryan, R. A., Arutyunyan, N. Kh., and Manukyan, M. M., The relaxation problem of prismatic beam bending (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 73–81, Jan./Feb. 1959.

The relaxation problem of prismatic rods having bi-axial symmetry with the material exhibiting nonlinear creep is considered. The solution of this problem reduces to that of finding the solution of a Volterra integral equation of the second kind. A solution is given which is applicable for a creep power law.

E. P. Popov, USA

6528. Rzhanitsyn, A. R., Considerations of humidity and temperature in creep problems (in Russian), *Trudi Mosk. Fiz.-Tekhn. In-ta* no. 1, 3–16, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8054.

To describe the development of creep phenomena in the presence of a time variation of the temperature-humidity state of the material, a stress-strain relationship of the form

$$\varepsilon(z) - \varepsilon_\theta(z) = \frac{\sigma(z)}{H} + \int_{-\infty}^{z} \sigma(\zeta)\, k\,(z - \zeta)\, d\zeta \qquad [1]$$

is proposed, which can formally be derived from the classical equation of the theory of hereditary elasticity [A. R. Rzhanitsyn: "Some problems of the mechanics of systems deforming in time," Gostekhizdat, 1949], by substituting therein for the ordinary (absolute) time t, of the observed deformation and the instant of application τ of the load pulse: correspondingly, a conditional time $z = \Psi(t)$, and $\zeta = \Psi(\tau)$; where Ψ is a particular function, determined experimentally, characterising the change in the physical and mechanical states of the material, conditioned by other than force factors.

Equation [1] can be used to describe the change in the temperature humidity state of a material in view of the fact that the heredity nucleus $k(z - \zeta)$ is invariant with regard to the conditional time, but not invariant in relation to the absolute time, (except in the trivial case that $z = mt + c$, $\zeta = m\tau + c$).

An example is given of the determination of the scale function of the conditional time for the temperature problem of creep in the presence of cyclic heating and cooling of the body throughout its thickness, according to the law $T = T_0 + B \sin \omega t$, where t_0, B ω are constants. For

$$k\,(z - \zeta) = \exp\left[-\frac{\eta E}{H}\,(z - \zeta)\right] \qquad [2]$$

Eq. [1] becomes transformed into the equivalent differential equation, starting from which a solution is given for the drying of an edge-constrained, thin plate, when the viscosity of the semi-liquid constituent of the structure changes in time according to the relationship $\eta = q_0 \exp(\nu t)$, where q_0 and ν are characteristic constants of the material.

The phenomenon of concrete creep in the presence of a finite setting time is also examined for the case that the conditional time can be expressed by the equation $z = z_0 + a^{-1} \ln t/t_0$, where z_0, a and t_0 are constants: both for a heredity nucleus of the type [2] and in the more general form

$$k\,(z - \zeta) = A\,(z - \zeta)^{\alpha - 1} \exp[-\beta\,(z - \zeta)]$$

where α, A and β are constants, and $\alpha > 1$.

M. I. Rozovskii

6529. Burlakov, A. V., The stress concentration at an aperture in a cylindrical surface in the presence of creep (in Russian), *Trudi Kbar'kovsk. Politekhn. In-ta* **14**, 59–70, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8057.

The problem indicated by the title is solved for the case that the theory of creep is represented by the theory of ageing under strain. It is assumed that the creep function (proportional to some degree of stress intensity) is constant over the thickness of the cylinder and does not depend on the coordinates of the cylindrical surface. On these assumptions (for which no justification is given), the problem is reduced to a solution for the elastic case. Applying the solution of A. I. Lur'e ["Statics of thin-walled cylindrical shells," OGIZ GITTL, 1947], author sets up expressions for the (stress) concentration coefficient, assuming the creep function to be independent of the coordinates.

Experimental data are presented on strain growth in perforated cylinders in the presence of creep. Lead cylinders were tested

at room temperature under internal pressure. No comparison of experimental with analytical data is made.

S. A. Shesterikov
Courtesy Referativnyi Zhurnal, USSR

6530. Makogon, M. B., The influence of the rate of strain on the compression strength of certain metallic solid solutions (in Russian), *Trudi Sibirsk. Fiz.-Tekhn. In-ta* no. 36, 3–20, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8276.

It is demonstrated that the characteristic, mechanical properties of solid solutions are determined by the degree and rate of strain. The influence of these conditions is particularly noticeable in low-melting metals. In the case of solid solutions existing in a state of disequilibrium (annealed Duralumin D1), the resistance to deformation does not decrease with decreasing rate of strain, as in the case of pure metals and ordinary alloys, but increases, which can be explained by strain-hardening as a result of disintegration of the solid solution, which is stimulated by plastic deformation. At the same time, the slower the rate of deformation, the greater the disintegration of the solid solution, and the consequent degree of strain-hardening. I. M. Gryaznov
Courtesy Referativnyi Zhurnal, USSR

6531. Odqvist, F. K. G., and Mellgren, A., Thermal stresses in long circular cylinders at periodic surface temperature variations, Proceedings of the Fifth Congress on Theoretical and Applied Mechanics, Univ. of Roorkee, Roorkee, India, Dec. 23–26, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., C. 1–C. 8.

Authors report briefly on research, sponsored by United States Air Force, relating to the influence of thermal stresses due to furnace regulation on creep rates of test specimens.

First, the temperature distribution is derived for the axisymmetric case of a long circular cylinder subject to surface temperature varying sinusoidally with time. Excluding thermal shock and assuming plane strain and elastic conditions, the thermal stresses are obtained. Diagrams show stress distribution and phase difference between stress and surface temperature for various temperature frequencies. Thermal stresses at high frequencies are seen to be concentrated near the surface. Numerical values are quoted for three cases; the stresses are too small to have significant effects in elastic conditions.

However, in long-time creep tests the creep rate may be influenced by thermal stresses. A correction formula is quoted for the secondary creep rate expression in terms of mean uniaxial stress. This correction is based on the assumption that the thermal stress is small in comparison with the mean stress. Thermal stresses given by elastic theory are used, and the dependence of the correction on temperature is deduced. It is claimed that, for the low frequencies of carefully controlled tests, the thermal stresses have negligible influence. Reviewer believes the value of the report could have been enhanced by further typical numerical evaluations.

S. Buchanan, England

6532. Shorr, B. F., On the analysis of nonsteady creep of nonuniformly heated bars of arbitrary cross section (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 89–96, Jan./Feb. 1959.

6533. Zadoyan, M. A., Creep of prismatic composite bars under constrained torsion (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 82–88, Jan./Feb. 1959.

6534. Smith, A. I., Mechanical properties of materials at high temperature, *Chartered Mech. Engr.* **8,** 5, 278–285, May 1961.

Plasticity

(See Revs. 6514, 6577, 6588, 6658, 6661, 6662)

Rods, Beams and Strings

(See also Revs. 6518, 6520, 6527, 6531, 6564, 6584, 6587, 6605 6606, 6608, 6609, 6622, 6678, 6699)

6535. Wilson, B. W., Characteristics of deep-sea anchor cables in strong ocean currents, A & M College of Tex., Dept. Oceanogr. & Meteorol. Rep. 204–3 A, 262 pp., Mar. 1961.

6536. Kalachev, I. B., and Talakin, N. I., A method of determining the elastoplastic characteristics of wire in torsion, *Indust. Lab.* **25,** 11, 1430–1431, Oct. 1960. (Translation of *Zavod. Lab. USSR* **25,** 11, 1368–1369, Nov. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

6537. Saad, S., and Hendry, A. W., Stresses in a deep beam with a central concentrated load, *Experimental Mech.* **1,** 6, 192–198, June 1961.

Photoelastic tests were carried out on three simply supported beams in which the ratios of depth to span were 0.67 : 1; 1 : 1; and 1.59 : 1. The cross section was rectangular. Results are summarized in figures showing the magnitude and direction of the principal stresses. The experimental stresses and those obtained from the finite differences method agreed reasonably well.

G. Sonntag, Germany

6538. Heller, S. R., Jr., The effect of geometry on the elastic properties of constant cross-section beams under symmetrically distributed loads, *J. Amer. Soc. Naval Engrs.* **73,** 2, 407–412, May 1961.

A beam with a constant cross section and a variable fixity at the ends is subjected to four (4) kinds of distributed load (triangular, sine, versed sine, parabolic), symmetrical with respect to the center of the span. The equivalent uniformly distributed load for each of the four cases is derived such that the same maximum stress is developed in the beam under the equivalent load as under the actual load.

Reviewer considers the results useful to stress analysis under dynamic loads, but considers the title of the paper quite misleading. D. H. Cheng, USA

6539. Wood, W. G., The distribution of shear stresses in an I section beam, *J. Roy. Aero. Soc.* **65,** 603, 198–200 (Tech. Notes), Mar. 1961.

6540. Terabasov, N. D., The bending analysis of multilaminar beams (in Russian), Raschety na Prochnost no. 2, Moscow, Mashgiz, 1958, 55–65; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8117.

An investigation of the bending deflection of beams built up of a number of interconnected plates, having different moduli of elasticity. The author is of the opinion that the example of the analysis of such a beam, given by S. P. Timoshenko and D. Lessels, "The applied theory of elasticity" (Gostekhizdat, 1931, p. 52), is incomplete, which may be a source of error in practical use; he examines this problem in greater detail, in its general form.

Comparison of the results obtained by the method recommended by the present author with those obtained by the correct application of the Timoshenko-Lessels method shows good agreement.

A. V. Dyatlov
Courtesy Referativnyi Zhurnal, USSR

6541. Frisch-Fay, R., The flexible leaf spring, *Austral. J. Appl. Sci.* **11,** 3, 341–352, Sept. 1960.

Paper discusses the deflection of a cantilever whose unloaded elastic curve is an arc of a circle and whose free end carries a load maintained in a direction perpendicular to the tangent plane at the fixed end. The deflection of the free end of the cantilever is given in terms of complete and incomplete elliptic integrals. However, the modulus which appears in these integrals is shown to have a limited range of applicability determined by certain critical shapes assumed by the elastic curve of the cantilever. This requires the evaluation of several moduli depending on the magnitude and direction of the applied load. The marked deviation from linearity for the load-deflection curve is shown in numerical examples. An error, which does not affect the remainder of the paper, appears in the first equation.

For a fuller description of the analysis the author refers to a 1959 paper, "On large deflections." *Austral. J. Appl. Sci.* **10,** 4, 418-32 [AMR **13**(1960), Rev. 5631].

W. J. Moreland, USA

6542. Harkanyk, I., The determination of the optimum bearing distance with regard to bearing stiffness in the case of shafts with constant and variable cross sections, respectively (in English), *Acta Techn. Acad. Sci. Hungaricae, Budapest* **33,** 1/2, 103–117, 1961.

Paper presents an exact solution for determining the optimum bearing distance of the cantilever beams with two supports, provided the cross section of the shaft is constant and there is no reaction moment present in the bearing planes. The bearing distance is considered to be the optimal one when the load required for the unit deflection on the cantilever tip, and acting there, is the maximum.

A numerical example is elaborated and is presented for practical application.

The survey is facilitated by a set of curves which is to be applied when the quotient of the overhang and of the solid shaft diameter $c/d = 1.2$. A formula with approximate accuracy is also presented and by means of it the value of the optimum bearing distance can quickly be determined when the ratio $c/d = 1.2$.

The second part of the study discusses a method, the accuracy of which can be considered as sufficient from the practical point of view. By applying this method the optimum bearing distance can also be determined in the case of any shaft with a variable cross section.

From author's summary by D. H. Cheng, USA

6543. Slitskenkhov, Iu. V., The application in the calculation of pin joints of the theory of continuously-supported beams with two characteristics (in Russian), *Naucbn. Dokl. Vyssb. Shkoly: Stroitel'stvo* no. 1, 141–149, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 8113.

Having noted the defects of Winkler's hypothesis, used in earlier investigations on pin joints, author applied the theory of the elastically-yielding and elastically-rotating foundation, regarding the external forces acting on the pin as known quantities. To determine the coefficients of compression and shear, tests were made of the penetration of a rigid punch, which enabled the final expressions to be set up for the strength analysis of pin joints. Comparison of the theoretical and experimental results show the greater suitability of the theory of the elastically-yielding and elastically-rotating foundation for consideration of the peculiarities of the structure of wood, compared with the theory of the elastic semi-space.

A. V. Dyatlov

Courtesy Referativnyi Zhurnal, USSR

6544. Flabov, V. A., The bending of a welded H-beam with rigid flanges (in Russian), *Sb. Leningrad In-ta Inzb. Zb.-d. Transp.* no. 156, 172–188, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 8116.

The case is analyzed of an infinitely long beam formed of flanges and a web. The top flange is acted upon by a force P, distributed over small segments of length $2c$, spaced at distances $2a$ between the resultants. The bottom flange is acted upon by a similar balancing force, displaced by the quantity a, with reference to the upper force. The stressed state of the web is determined by solving the two-dimensional problem of the theory of elasticity for an infinitely long strip acted upon by a periodically applied load. The boundary conditions are found from an examination of the bending deflection of tee flanges, by the elementary methods of the theory of elasticity. The solution is conducted to termination only for a single numerical example. It is necessary to point out the inadmissibility of using the elementary formula [21] for determining the stresses σ, perpendicular to the axis of the beam, since this formula is correct only for a uniformly distributed load. The error is the more considerable in that the height of the flange is not negligible compared with the height of the web. In the plotted curves, the stresses σ_x change discontinuously at the points of contact between the flange and the web. This is a consequence of the inaccuracy of the solution, in which it is assumed that, with a stepwise variation of the thickness of the web, the σ_y stresses also experience a discontinuous change. The author, apparently, is unaware of the researches of B. N. Zhemochkin ["The plane problem of the analysis of an infinitely-long beam on an elastic foundation," VIA, RKKA, 1947], and Riewe [I. Riewe, *ZAMM* no. 7/8, 1948], in which the conditions in the plane of contact of the flange and the web, and the influence of the nonnegligible height of the flange, are very thoroughly investigated. It follows from these researches that the admission of free sliding of the flange on the web introduces only an insignificant error in the magnitude of the stresses. This agrees with the conclusions of B. M. Brande ["The distribution of a concentrated pressure in metal beams" Stroiizdat, 1950].

G. M. Chuvikin

Courtesy Referativnyi Zhurnal, USSR

6545. Gorbovskii, B. E., The stability of flexible, oval rings under the action of concentrated forces (in Russian), *Naucbn. Dokl. Vyssb. Shkoly: Stroitel'stvo* no. 1, 88–92, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 8090.

An analysis of the stability of a symmetrical, oval ring of constant cross section, symmetrically loaded by four concentrated forces, on the assumption that the displacements are finite. The natural system of coordinates is used in the analysis. The equilibrium of a quadrant of a ring, carrying crossheads at the ends, is investigated. A differential equation is set up for the elastic axis of a flexible bar. The solution of this equation is obtained by an approximation method of equivalent linearization. A relationship is found between the parameter of the load and the form parameter of the ring, representing the stability conditions; in particular, the critical ratios for a circular ring are stated.

Yu. S. Shkenev

Courtesy Referativnyi Zhurnal, USSR

6546. Brandt, H. E., On the torsion of a rectangular beam with diametrically opposite sides of the form ax^n, *J. Aerospace Sci.* **28,** 6, 503–505 (Readers' Forum), June 1961.

Example is given of Kantorovich's modification to Galerkin's approximate method of solution of differential equations. Reasons for using the method are not discussed.

L. H. Mitchell, Australia

6547. Birman, S. E., Constrained torsion of thin-walled bars of closed rectangular cross-sectional profile with transverse diaphragms (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 19–29, Jan./Feb. 1961.

After studying some simple cases of plane strain in thin webs and flanges of rectangular section the stresses and the angle of torsion of a thin-walled axisymmetric rectangular box of constant section are obtained by superposing some of the plane strain solutions. Stresses in boxes with one end clamped and the other reinforced by a diaphragm, which is rigid in its own plane, are determined for the case of a uniformly distributed and of a concentrated torsional moment. The stress problem in boxes with more diaphragms and with arbitrary distributed torsional moments is treated separately and the equilibrium system of forces in intermediate diaphragms is obtained from the assumption that the distorsion of box sections in their own plane is zero at every diaphragm. Sections with stringers in corners can be dealt with in the same manner, if their influence on shear can be neglected. Numerical results are compared with those obtained under the assumption of continuously distributed diaphragms and it is shown that in a typical case the difference in the expression for the angle of torsion is less than 3%. A. Kuhelj, Yugoslavia

Plates, Shells and Membranes

(See also Revs. 6512, 6513, 6584, 6590, 6591, 6593, 6595, 6596, 6597, 6599, 6600, 6613, 6641, 6929)

6548. Simmonds, J. G., The general equations of equilibrium of rotationally symmetric membranes and some static solutions for uniform centrifugal loading, NASA TN D-816, 54 pp., May 1961.

General equations of equilibrium of rotationally symmetrical shells undergoing large arbitrary deflections but small strains are derived by principle of virtual work. Static solutions of equations for steadily rotating membranes are considered for cases where final or initial configuration of membrane is specified.

From author's summary by G. W. Housner, USA

6549. Kalmanok, A. S., The analysis of rectangular membrane plates by analogy with doubly-curved, flat shells (in Russian), Rasschet Prostranstv. Konstruktsii no. 4; Moscow, Gosstroizdat, 1958, 415–450; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7967.

On the basis of V. Z. Vlassov's theory of doubly-curved flat shells ["General theory of shells and its engineering applications," Moscow-Leningrad, Gostekhteorizdat, 1949], and using the method of complex transformation of the fundamental equations of this theory, suggested by V. V. Novozhilov ["Theory of thick shells," Leningrad, Sudpromgiz, 1951], as well as the method of analysis of rectangular plates earlier developed by the present author, some problems are examined relating to the analysis of rectangular flat membranes under transverse loading.

First, the case is examined of a membrane plate freely supported on all edges by radial supports, assumed henceforth, by analogy with the methods of the structural mechanics of bar frames, to be the fundamental system. With this assumption, problems are examined of the calculation of membrane plates having a freely-supported pair of opposite sides of the contour; as well as of plates not having any freely-supported edges.

As an example of the application of the suggested methods, the case is examined, in detail to the extent of a numerical analysis, of a square membrane plate under different boundary conditions on the contour, on the assumption that the material of the plate has a zero value of the Poisson ratio.

This latter assumption substantially simplifies the problem, since it dispenses with consideration of the special additional loads necessary to standardize the classical infinite system of equations for this case.

The numerical data of the complete calculation have confirmed the material influence of the membrane effect of the plates on the reduction of their bending deflections and bending moments—in particular, for the case of fixed supports, taking up the lateral thrust. S. V. Aleksandrovskii

Courtesy Referativnyi Zhurnal, USSR

Book—6550. Timoshenko, S., and Woinowsky-Krieger, S., Theory of plates and shells, 2nd ed., New York, McGraw-Hill Book Co., Inc. 1959, xiv + 580 pp. $15.

This book is so well-known that it will suffice to consider the changes in this first revision. These are chiefly additions to include important work done since the first edition of 1940. The text has been increased by more than a third, but by using thinner (and not entirely opaque) paper, and resetting with smaller margins, etc., the new book is thinner than the old.

Old material omitted is on buckling of plates, more completely covered in the senior author's "Theory of elastic stability." Additions to plate theory include: effects of Poisson's ratio, of interest for experimental methods; expansion of discussion of Navier's solution; Reissner's and Green's treatments of transverse shear effects; and numerous new rectangular plate cases, including expansion of the treatment of continuous and elastically supported plates; skewed plates and stress concentrations due to holes; a great expansion of the discussion of approximate methods and of anisotropic plates, and some new cases of combined lateral and direct loading and large deflections.

The last quarter of the book, devoted to shells, has been slightly expanded by inclusion of the stress function method in membrane theory and a few new cases, but it remains primarily a book on plates, and an indispensible one. Perhaps the authors will give us a new book to cover the enormous literature on shells.

L. H. Donnell, USA

6551. Tiffen, R., An investigation of the transverse displacement equation of elastic plate theory, *Quart. J. Mech. Appl. Math.* **14,** 1, 59–74, Feb. 1961.

Equations for bending of a plate are derived from the theory of elasticity. A system of exact equations for the nth moment of the lateral deflection about the x-y plane is derived. It is found that the usual plate equation is a first approximation to the exact equations for the mean value of the transverse displacement. The nature of the differential equation for the mean value of lateral displacement that must be used to achieve a specified order of accuracy is found to depend on both the order of accuracy required and the order of magnitude of the mean displacement relative to the thickness of the plate. E. H. Dill, USA

6552. Dyrbye, C., and Johansen, K. W., An iterative method of calculation for axial symmetric plates with bending as well as membrane stresses (in English), *Bygnsstat. Medd.* **31,** 3, 77–92, Dec. 1960.

Authors develop a method for solving the large deflection bending of circular plates under axisymmetric loading. Starting with the large deflection equations as given by Timoshenko ("Theory of plates and shells"), authors form two integral equations for the stress function and deflection function, in a form convenient for an iterative numerical solution.

The method is illustrated by solving the problem of a thin circular disk with a central hole, uniformly loaded along its inner edge, and simply supported along its outer edge. The solution is

carried out for a single value of applied load. The intermediate steps of the iteration are tabulated in order to demonstrate the apparent convergence of the solution. A. L. Ross, USA

6553. Mukhopadhyay, S. K., The "unified" influence diagram method—a new approach to analysis of plates, *J. Technol., Calcutta* **4,** 2, 157–169, Dec. 1959.

Use is made of the concept of images in order to extend to rectangular plates of all possible side ratios, as well as to triangular equilateral or right-angled isosceles plates, the application of "master influence diagrams" constructed for an infinite strip. Examples show how a point load is transformed by reflections in an infinite series of loads; however, as load effects die away with increasing distance, only a few images are to be taken into account. The method applies to particular boundary conditions (simple support along the reflecting sides). P. Cicala, Italy

6554. Basuli, S., Note on the bending of a thin uniformly compressed circular plate under an eccentric concentrated load (in English), *ZAMM* **41,** 5, 217–219, May 1961.

Generalization of classical Clebsch solution (see Timoshenko's text) for an uncompressed plate, with Bessel functions of integral order replacing powers of r in the series solution.

R. A. Clark, USA

6555. Grigor'ev, A. S., Plates of uniform bending strength (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **25,** 45–50, 1959.

6556. Sheremet'ev, M. P., Bending of an infinite plate weakened by an elliptical hole, the edge of which is reinforced by a ring (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **25,** 51–63, 1959.

6557. Kurdin, N. S., Bending of partially loaded rectangular plates with two simply supported and two free edges (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **25,** 104–110, 1959.

6558. Osedel'ko, A. I., The problem of the bending of a rectangular, rigidly-constrained plate (in Russian), *Sb. Tr. Voronezbsk. Inzb.-Stroit. In-ta* no. 4, 63–68, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 7984.

It is known that, in the first approximation, the results of solution of the problem of the bending of plates by the variational method depend substantially on the selection of the direction (longitudinal or transverse) of the elementary beam strip.

Applying a suggestion by V. Z. Vlassov [*Prikl. Mat. Mekb.* **10,** no. 1, 1946], author demonstrates on the example of a rectangular plate, constrained on all edges, that this restriction, associated with the selection of the direction of the elementary beam strip, can be eliminated if the approximating function of the bending deflection of this elementary strip is replaced by a new function, resulting from a solution of the problem in the first approximation.

For rectangular plates with an aspect ratio of 1.0, 1.5 and 2.0 respectively, it is found that (independently of the selected direction, whether longitudinal or transverse) the results of a solution in the second approximation differ from the rigorous solution by not more than 3%. B. N. Lopovok

Courtesy Referativnyi Zhurnal, USSR

6559. Au, T., and Hribar, J. A., On the solution of thin elastic shells of revolution, *J. Aerospace Sci.* **28,** 6, 510–511 (Readers' Forum), June 1961.

For axisymmetric normal load, authors give stress-strain relations which are one of the possible improvements of Love's first approximation discussed by Knowles and Reissner [AMR **12**(1959), Rev. 3817], together with a set of equilibrium equations which include the effect of edge rotation. The equilibrium equations are equivalent to those used by Reissner [AMR **12**(1959), Rev. 5976]. Authors then omit curvature terms in the normal force equations and edge rotation effect in equilibrium equations, and give a formal solution in terms of transverse shear and edge rotation. For comment on the theoretical and practical value of various results obtained by different approximation processes, reviewer suggests *Math. Rev.* **15,** p. 579, 1954 (review by C. Truesdell) and a recent book by V. V. Novozhilov, p. 52–54 [AMR **13**(1960), Rev. 2749].

R. Dunholter, USA

6560. Chernykh, K. F., Conjugate problems of the theory of thin shells, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 74–79.

R. Hill [*J. Mech. & Phys. Solids* **4,** 1–9, 1955; AMR **8**(1955), Rev. 404] and others have shown the existence of related or conjugate problems in plane elasticity, where knowledge of the solution of one problem satisfying given boundary conditions immediately determines the solution of a second problem with a different set of boundary conditions. The present paper shows that the same phenomenon occurs in linear shell theory. Using Novozhilov's [AMR **13**(1960), Rev. 2749] formulation of shell theory in terms of complex-valued stress and displacement quantities, explicit formulas are given relating the boundary conditions of two conjugate problems. R. A. Clark, USA

6561. Zerna, W., New developments in shell theory (in German), *ZAMM* **41,** 3, 97–101, Mar. 1961.

An expository paper reviews basic equations of the linear theory of elastic shells in tensor notation. Various special theories are listed with some discussion of their limitations.

R. A. Clark, USA

6562. Das Gupta, N. C., Using finite difference equations to find the stresses in hypar shells, *Civ. Engng., Lond.* **56,** 655, 199–201, Feb. 1961.

The problem of determining the stresses in hyperbolic paraboloidal shells under uniform lateral pressure is solved by the method of finite difference approximations of the differential equations. Two partial differential equations are derived by the author which consider both membrane and bending stresses in the shell. The author derives the equations for a general surface loading and then further restricts the equations to the case in which the pressure is perpendicular to the projected flat surface.

The author solves a numerical problem by using finite difference equations for shell dimensions comparable to experimental results obtained by the Cement and Concrete Association Research Laboratory. For the finite difference approximation the plan area of the shell is divided into an 8 by 8 uniform mesh. The results of the analysis are tabulated and shown graphically. The author notes that in the vicinity of the edges both bending moments and membrane stresses vary rapidly and that greater accuracy could possibly be achieved by taking a closer mesh and suitable extrapolation.

It could also be noted that for a problem of this sort a more advantageous use of the finite difference equations might be achieved by using a nonuniform mesh spacing, i.e. a finer mesh near the edges than near the central portion of the shell.

A. L. Ross, USA

6563. Casacci, S., and Picollier, G., Study of bending conical shells of varying thickness under centrifugal stress (in French), *Houille Blanche* **16,** 1, 46–58, Jan./Feb. 1961.

Authors derive two integral equations of the Fredholm type to study the axisymmetrical bending of shell structures of revolution

with varying thickness. By means of Simpson's method, the integral equations are transformed into a system of $2n$ linear equations, the solutions of which are expressed in n values of the displacements, where n represents the number of equidistant points along the middle surface.

Stresses and strains based on $n = 11$ and $n = 17$ are calculated for linearly varying-thickness conical shells subjected to centrifugal loads and are compared with a hypergeometric series solution obtained by A. D. Kovalenko ["Plaques et enveloppes dans les rotors de turbomachines," Edition de l'Academic des Sciences de la R.S.S. de l'Ukraine, Kiev, 1955, p. 222–257]. Good agreement of both investigations is indicated.

The contribution of paper is the presentation of a method which avoids usual introduction of a complex function for which limited numerical tables are available. L. A. Scipio, USA

6564. Silverj, D. G., Cylindrical self-supporting shells, comparison of balanced beam and membrane solutions (in Italian), *G. Gen. Civ.* **99**, 2/3, 148–163, Feb./Mar. 1961.

Investigation is made of conditions under which the Mc/I beam solution may be used and when the membrane solution may be used instead of the exact solution. Graph is given from which it can be determined if span, radius and thickness of shell are such that shell can be analyzed as beam or as membrane, dividing line being put at point of equal error compared to exact solution.

G. W. Housner, USA

6565. Vainberg, D. V., and Siniavskii, A. L., Approximate analysis of shells with holes by the methods of potential theory, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 570–581.

A general procedure for constructing solutions to equilibrium problems for the bending of thin shells is described. The calculations leading to an approximate solution of the problem of a cylindrical shell under uniform tension, with simply supported ends, and having a hole, which becomes an ellipse upon development of the cylinder into a plane, are outlined. Numerical results for the lateral deflections are presented for one particular size of hole in one particular size cylinder. The results show that not only does a concentration occur in the membrane stress but also the lateral deflections lead to significant bending stresses.

The method of solution is based upon replacement of the three differential equations for displacements by a set of two differential equations, analogous to the equations of plane stress, for the tangential displacements plus an integral equation, which depends only on the boundary values of the tangential displacements, for the lateral displacement. The differential equations are then solved by the method of Muskhelishvili. In the numerical example, an approximate solution is obtained by truncation of a Fourier series. E. H. Dill, USA

6566. Markus, J., Analysis of rotationally symmetric shells composed of composite structures by the Cross process (in German), *Beton u. Stahlbeton.* **55**, 10, 235–239, Oct. 1960.

Systems of symmetrically loaded shells having form of a surface of revolution and with displaceable edges are studied employing Geckeler's solution. The statically undetermined actions along the edges are obtained by applying the deformations method by which, utilizing Cross' method, the unknown quantities are reduced to the sole displacement: a δ arbitrary displacement having been impressed in correspondence with an edge, the horizontal stresses, and the moments, as a function of the unknown δ quantity (after the mutual rotation of the tangents to the slabs in one single point has been allowed) are determined; from the condition of equilibrium to the translation, δ is obtained, then the stress values at the edges. For the application of the rigidities to the rotation and of the deformations method to systems of shells, some knowledge of "Science of constructions" by O. Belluzzi [Zanichelli Press Editors (Bologna)], Chapter XXVIII, 1951, is found to be useful. P. Pozzati, Italy

6567. Dawoud, R. H., Symmetrically loaded shallow shells of revolution, *Mathematika* **7**, 13, 23–35, June 1960.

The author considers the flexure of shallow elastic spherical thin shell supported by a ring girder and subjected to uniformly and parabolically distributed normal load, meridional surface traction, and concentrated loads at the apex of the shell. All problems are rotationally symmetric. References given in this paper overlook all Russian contributions in the engineering theory of shallow shells with the sole exception of Pasternak. In fact the differential equation developed in this paper was treated by Vlasov, Ambartsumyan, Rabotnov and several others more than a decade ago. A short discussion of this simplified equation is given in Vlasov's "Obshchaya Teoriya Obolochek," 1949. The same differential equation has been also treated in an article by Tsuboi and Akino in the *Report of the Industrial Science, Univ. Tokyo* **5**, no. 4, 1955, and in *Publ. Int. Assn. Bridge Struct. Engng.* **15** [AMR **10**(1957), Rev. 686], which considered the shallow spherical shell at some length for constant as well as variable shell thickness .

The results on the evaluated integration constants for parabolic and tractional loads are new, as far as the reviewer is aware. Despite some repetition in this paper it is of practical significance and deserves a study by any engineer engaged in thin-shell design.

G. Ae. Oravas, Canada

6568. Cicala, P., On the elastic theory of a thin partition with a ruled middle surface (in Italian), *Atti Accad. Sci., Torino* **95**, 62–68, 1960/1961.

In a paper under publication [*Atti Accad. dei Lincei*] to which extensive references are made the author has obtained elastic solution for a thin partition with a particular form of the middle surface. The method has now been extended to developable and nondevelopable surfaces. No boundary conditions are considered.

B. R. Seth, USA

6569. Svirskii, I. V., Utilization of similarity considerations for the improvement of the convergence of a process of successive approximation in shell analysis, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24**, 1, 177–190, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

Author describes an iteration method for solving the coupled shallow shell equations for stress function Φ and transverse displacement w. Method starts by substituting assumed w into equation with highest Φ derivative and solving for Φ; then reversing the procedure. Not only are boundary conditions satisfied at each step n, but also certain mutual orthogonality conditions between Φ_n and Φ_{n-1}, w_n and w_{n-1}. These latter conditions yield relations between plate thicknesses h_n and h_{n-1} and transverse load amplitudes p_n and p_{n-1}. Both h and p change from step to step, thereby improving convergence. Application of the method is made to the bending and stretching of a long simply-supported plate and of a clamped circular plate. W. E. Jahsman, USA

6570. Rudiger, D., Contribution to the theory of elastic shells (in German), *Ing.-Arch.* **28**, 281–288, Mar. 1959.

6571. Matildi, P., Calculation of thin, flat translation-shells over a rectangular plant (in Italian), Atti Ist. Sci. Costr. Univ. Pisa no. 66, 51 pp., 1959.

Author presents the bending theory of flat translation-shells considering especially the type of shell originated by a curved generatrix sliding on directrices in vertical planes. The shell is rectangularly shaped and may possess different boundary conditions. The first part deals with the deduction of the general equations of equilibrium and compatibility, transforming these in only one resolvable equation using complex functions with a real variable. Particular cases are easily derived by this general case, obtaining, for example, the characteristic equations of Reissner and von Kármán as well as the trivial cases of the plane plate and the cylindrical tower. The second part gives an approximate solution of the differential equation stated in the first part, applying the well-known function of damped oscillations. With this solution it is possible to compute the stresses and deformations in the shell and to take into account particular boundary conditions. The third part presents some examples of practical use, considering the influence of the rise-span ratio on the damping characteristics of the stresses starting from the edges.

Reviewer thinks that author's investigations are very valuable. They explain the static behavior of a useful type of translation shell.

H. Beer, Austria

6572. Khlebnoy, Ya. F., The problem of integration of the equations of shells of rotation under axially symmetrical loads (in Russian), Rasschet Prostranstv. Konstruktoii no. 4; Moscow, Gosstroizdat, 1958, 361–392; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7969.

The solution is examined of the cases of a circularly cylindrical shell with a linearly varying wall thickness; a conical shell with a constant wall thickness; and a flat, spherical shell with a constant wall thickness. The solution is developed, by the simplest method, of the problem at the boundary, leading to the solution of Bessel, differential equations. The solution of these Bessel equations is found by the simple and objective method of asymptotic integration called the Stokes method of asymptotic resolution of Bessel functions. The limits of applicability (validity) of the solutions are indicated; the coefficients of the classical equations of the method of forces are derived, and formulas set up for determining the magnitudes of the stresses, depending on the forces acting at the boundary. As a sample calculation, the boundary stresses are determined for a conjugation of a conical dome, a bearing ring, and a cylinder with varying wall thickness, representing a water tank of reinforced concrete.

L. Yu. Poverus

Courtesy Referativnyi Zhurnal, USSR

6573. Giencke, E., Stress analysis of wings of small aspect ratio with the aid of plate theory (in German), *Z. Flugwiss.* **9**, 3, 65–80, Mar. 1961.

Composite wing structure of small aspect ratio is assumed to be an equivalent plate. The plate equation is solved in two ways. The first consists of expanding the plate deflection in the form $w = \sum_m \psi_m(x) y^m$, x and y being in the directions of the span and chord, respectively. This procedure is thus an extension of that adopted by previous authors who used the first two or three terms of the series. The second procedure makes use of a more general form $w = \sum_m \psi_m(x)\, W_m(y)$ and avoids the slow convergence of the first.

Y.-Y. Yu, USA

6574. Paslay, P. R., Design of flapper valves, *ASME Trans.* **83** B (*J. Engng. Industry*), 1, 92–96, Feb. 1961.

Author investigates the elastic behavior of a flapper valve, which is a thin flat circular disk with radially cantilevered fingers, supported at their ends, while the disk is loaded with a uniform transverse pressure. The elastic strain energy is expressed in terms of six parameters—the deflection, radial displacement and slope of the disk for the section with a finger and for the midway section between two fingers—with the assumptions that the radial section of the disk undergoes a rigid radial displacement only, and the displacement of the finger determined by the beam theory. These parameters are later found when the potential energy is minimized. It is shown that the deflections and stresses versus load are nonlinear, results which are typical to large deflections of circular plates with or without a central hole. Curves for a numerical example are presented.

Z. Kami, Israel

6575. Dolpher-Larsen, E., Rigid plate resting on a semi-infinite elastic solid (in English), *Bygnsstat. Medd.* **32**, 1, 39–45, May 1961.

Paper resolves problems by Bessel-Fourier transforms, namely concentrated load, ring load, paraboloidal load of revolution, as well as elliptic plate. The latter problem is only indicated. Reviewer believes paper is too condensed, so that usefulness is limited.

G. Sonnemann, USA

6576. Friedrichs, K. O., and Dressler, R. F., A boundary-layer theory for elastic plates, *Comm. Pure Appl. Math.* **14**, 1, 1–33, Feb. 1961.

The boundary or edge layer considered is of width comparable to the plate thickness. Using three-dimensional linear elasticity and a systematic perturbation procedure involving expansions of all quantities in powers of the plate thickness, the pure bending problem is shown to yield the equations of classical pure-bending theory of a thin plate as a first approximation. Next, in order to establish appropriate boundary conditions from a three-dimensional point of view, the transition from arbitrary three-dimensional stress loadings over the edge of the plate to resultant values of stress effective in the plate interior is considered. Here, a "stretching transformation" similar to that used in fluid mechanics reduces the transition problem in the edge layer to the consideration of (a) a plane-strain problem for a semi-infinite strip with self-equilibrating stresses on the end and (b) a torsion problem with the same semi-infinite strip as the torsional cross section. These two problems must be analyzed for each of the successive sets of stress quantities involved in the perturbation scheme. In this way boundary conditions for the stress resultants and bending couples of various successive approximation theories can be determined. For a first approximation, which is classical plate theory, the well-known Kirchhoff boundary conditions are obtained. However, the present analysis shows that Michell's theory of "moderately thick" plates (described in Love's *Treatise*) is not applicable in general even away from the edge of the plate; in particular, Michell's theory is not applicable when there is a free edge.

Although in principle it appears that the present approach can be extended to obtain a complete second approximation or "thick plate theory" for the bending problem including appropriate boundary conditions, the authors do not carry their analysis that far.

R. A. Clark, USA

6577. Langenbach, A., Elasto-plastic deformation of plates (in German), *ZAMM* **41**, 3, 126–134, Mar. 1961.

Nonlinear fourth-order differential equation under consideration is generalization of well-known biharmonic equation in classical small-deflection theory of elastic plates. Derivation, attributed to L. M. Kachanov, is based on simplified Hencky theory of plasticity with arbitrary law of strain hardening under assumptions that middle plane is unstrained, that material is incompressible, and that

linear geometric relations of Kirchhoff theory apply. Equivalent variational formulation of theory is developed directly from consideration of differential equation. Variational theory is used to study existence and uniqueness of solutions of boundary-value problems and convergence of minimal sequences.

H. L. Langhaar, India

6578. Dill, E. H., General theory of large deflections of thin shells, NASA TN D-826, 21 pp., Mar. 1961.

A general theory is developed for the case of thin shells with large deflections and small rotations. This is an extension of the theory of Green and Zerna [AMR **8**(1955), Rev. 2996] and differs from that theory mainly in the retention of some higher terms in the expression for the strain tensor of the middle surface in terms of the derivatives of the displacements. As in the Green and Zerna development, the theory yields a fourth-order differential equation in a stress function. This equation is examined in detail in the case of surfaces of revolution and particularly conical shells.

S. Gratch, USA

6579. Lie, K.-H., The theory of oblique-angled anisotropic plates and its application to skew bridges (in German), *Scientia Sinica* **7**, 2, 151-163, Feb. 1958.

Equation of bending of anisotropic skewed plates is presented and applied to the analysis of skew bridges. Oblique coordinates are used.

Y.-Y. Yu, USA

6580. Sobolevski, V. M., The elastically stressed state of an anisotropic, rotating, circularly-cylindrical tube influenced by centrifugal forces, internal and external pressures, an axial force, and a radial heat flow (in Russian), *Dokladi Akad. Nauk BSSR* **2**, 3, 91-99, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7948.

The stress condition is investigated of a circularly-cylindrical tube, having cylindrical anisotropy and transverse isotropy with reference to the radial direction, rotating with a constant, angular velocity, and influenced by internal and external pressures, an axial force, and a radial heat flow.

A solution is also presented for the case of the deformation of a circularly-cylindrical tube consisting of a plurality of concentric layers possessing cylindrical anisotropy and transverse isotropy, with reference to the radial direction, on the assumption that the layers are rigidly connected.

V. A. Lomakin

Courtesy Referativnyi Zhurnal, USSR

6581. Sazonov, R. M., The analysis of slabs of large extent near the edge (in Russian), Sb. Inform. Soobshch. po Nauchno-issled. Rabotakh Vypolnen. Vyssh. Uchebn. Zavodeniyami; Stroit. Konstruktsii, Kiev, 1958, 56-58; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7982.

The problem is investigated of the bending of a semi-infinite slab, resting on an elastic semi-space, by a force applied in the vicinity of the edge of the slab.

The surface of the slab is divided into a series of elementary areas. The degrees of settling of the foundation are determined for the centers of these areas. The differential equation of the slab is replaced by an equation with finite differences. The bending deflections of the slab are equated to the settling of the foundation in the particular points. At the edge of the slab, the equations are formed from the condition of zero bending moment and total reaction along the edge.

The pressures in the centers of the areas are determined from an infinite series of linear algebraic equations. By solving a truncated system, author obtains the pressure distribution in the vicinity of the points of application of the forces.

Curves of the pressure distribution under the sole of the slab are given.

B. I. Mossakovskii

Courtesy Referativnyi Zhurnal, USSR

Buckling

(See also Rev. 6678)

6582. Leipholz, H., The buckling of toroidal bars with concentrated and continuous longitudinal forces (in German), *Ing.-Arch.* **30**, 1, 42-56, Jan. 1961.

The problem is reduced to the integration of a system of second-order linear differential equations with variable coefficients. The following boundary conditions are considered: ends free from transverse shear forces, clamped ends, and fixed ends.

The solution of the homogeneous equations is developed for the case of zero transverse shear forces at the bar ends and for zero or constant longitudinal force; the solution is expressed by means of Bessel functions $J_{\frac{1}{3}}$ and $J_{-\frac{1}{3}}$.

The solution of the nonhomogeneous equations is examined for the case of clamped ends and for a zero or constant longitudinal force.

Detailed numerical examples illustrate the theory.

M. V. Soare, Roumania

6583. Csonka, P., Buckling of bars elastically built-in along their entire length (in English), *Acta Techn. Acad. Sci. Hungaricae, Budapest* **32**, 3/4, 423-427, 1961.

This paper deals with the determination of the critical force of centrally compressed bars elastically built-in along their entire length. It is proved that the deflection curve of an elastically built-in bar is the same as if the bar were not built-in elastically. The critical force of the bars dealt with is greater by the coefficient of the elastic embedding than for elastically not built-in bars.

From author's summary by C. F. Kollbrunner, Switzerland

6584. Protte, W., A treatment of the problem of general instability of cross-stiffened beams with regard to lateral buckling (in German), *Stahlbau* **30**, 4, 103-113, Apr. 1961.

Title problem is investigated without conventional assumption of rigid body motion of cross section. Solution is obtained through customary energy approach and use of high-speed digital computer. Paper contains little that is fundamentally new but gives number of interesting numerical results. These confirm that lateral stability limit of beams may be raised beyond value predicted by conventional theory through introduction of stiffeners exhibiting both bending and torsional stiffness.

E. F. Masur, USA

6585. Gerasimov, A. V., Investigation of the stability and the possibility of losing the stability of a rectilinear form of embedded pit-prop (in Russian), Nauchn. Probl. Vskryitiya i Razrabotki Mestorozhd. Polezn. Iskopaesnyikh, Moskva, Akad. Nauk, SSSR, 1959, 230-243; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13538.

Paper begins with an account of the known data on stability and the coefficients of stability. Using the linear theory, the author obtains a formula for the coefficient of stability with consideration for the overflow of the liquid ballast. An investigation follows on the stability of an embedded prop presented as an undeforming body of rotation (tube) with a bottom and a symmetrical weight distribution. Author computes the coefficient of stability after an examination of the static moments of all the forces acting on the prop relative to the plane of declination of the prop. An analysis is given of the expression for the coefficient of stability and relevant recommendations are suggested.

A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR

6586. Neustroiev, B. F., The energy method in the theory of the stability of bar systems (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Str-vo i Arkhitekt.* no. 1, 59-73, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8100.

A method of calculating the stability of plane frames is examined, founded on the possibility of expressing the potential energy of an elastic bar system by a corresponding quadratic form in which the variables are the rotations and displacements of the joints, and the coefficients, the "reactions" according to the method of deformation. A table of auxiliary formulas is given. It is pointed out that the longitudinal forces must be taken into account when calculating the potential energy.

The principal contents of the paper are a series of general propositions (termed theorems) stated without any references to the theorems of the theory of quadratic forms and the theorems of their limiting values. L. K. Narets

Courtesy Referativnyi Zhurnal, USSR

6587. Sherbourne, A. N., Bolted beam to column connexions, *Struct. Engr.* **39,** 6, 203–210, June 1961.

6588. Haaijer, G., and Thurlimann, B., Inelastic buckling in steel, *Trans. Amer. Soc. Civ. Engrs.* **125,** Part 1, 308–344, 1960.

The interest of buckling in the inelastic range is enhanced by the advance of plastic design methods due to the assumption that local buckling of flange and webs of WF beams will not occur during the formation of plastic hinges. Experimental results presented in this paper show that steel columns and plates can be compressed beyond yield point and even into strain-hardening range without buckling. The test results were compared with the results of a theoretical investigation which was mainly presented in a previous paper [G. Haaijer, "Plate buckling in strain hardening range" *Trans. Amer. Soc. Civ. Engrs.* **124,** 1959]. Some transition curves were suggested for buckling between the elastic limit and the yielding stress. K. H. Chu, USA

6589. Habel, A., Buckling formulas for free standing frames (in German), *Beton u. Stahlbeton.* **55,** 10, 225–230, Oct. 1960.

Through the use of usual analytical procedures the conditions of instability of some simple frames recurring in engineering practice are given: A case concerning a 3-span symmetrical frame and another one regarding a 2-span frame are examined. The loads are concentrated on the nodes and the members have a constant section. Some reference is made to German practises.

P. Pozzati, Italy

6590. Gazizov, B. G., The Bubnov-Galerkin method and estimate of its accuracy in a stability problem of a plate (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 168–171, Nov./Dec. 1960.

Author considers the elastic stability of thin circular ring plates with unsupported edges subjected to uniformly distributed radial stresses along these edges. The critical loads for out-of-plane buckling of the ring are determined by finding an exact solution and again using the Bubnov-Galerkin method. The latter procedure yields a 6% error. E. P. Popov, USA

6591. Almroth, B. O., and Brush, D. O., Buckling of a finite-length cylindrical shell under a circumferential band of pressure, *J. Aerospace Sci.* **28,** 7, 573–578, 592, July 1961.

Theory is developed for the elastic buckling of a circular cylinder subjected to an axisymmetrical band of external pressure. The analysis is based on the principle of minimum potential energy together with the Rayleigh-Ritz procedure of expanding the displacements in trigonometric series. The paper is an extension of a previous one by D. O. Brush from the case of the infinitely long shell to one of finite length. Unfortunately, the rotational restraint at the boundaries of the cylinder are not explicitly stated, nor is the influence of rotational restraint investigated. Rotational restraint becomes increasingly important as the length of cylinder decreases.

The results of three tests indicate good agreement with theoretical buckling pressures. No comparison is made, however, between the number of buckle lobes observed and those predicted theoretically. The number of lobes proves useful when reinforcement is designed to increase buckling strength. This reviewer would like to see results of additional tests exploring various b/L and L/R ratios.

Good features of the theory are that it reduces very closely to Flügge's solution in which the pressure is applied over the entire lateral surface and, also, to Hahne's solution in which the pressure is concentrated along a circumferential line.

M. E. Lunchick, USA

6592. Brown, J. K., Rea, R. H., and Breuer, D. W., An experimental study of buckling of thin-walled, pressurized, conical shells under compression and compression-bending interaction, *J. Aerospace Sci.* **28,** 6, 506–507 (Readers' Forum), June 1961.

Compression and compression-bending tests on thin-walled cylinders and cones with internal pressure are described and compared with results reported by Lofblad ["Elastic stability of thin-walled cylinders and cones with internal pressure under axial compression," TR No. 25-29, Office of Naval Research Contract No. Nonr-1841(22), Mass. Inst. Technol., May 1959].

The data were limited to tests of two cones and cylinders. Results indicated several differences in behavior of the conical shells. Authors felt the differences may be due to initial imperfections as well as end conditions.

Although the tests were too limited to support this conclusion, reviewer feels the conclusion to be sound. An analytical and experimental study conducted by the reviewer and his group showed the behavior of shells of revolution to be highly sensitive to initial imperfection. L. A. Scipio, USA

6593. Ebner, H., and Schnell, W., Buckling of circular cylindrical shells with "stepped" wall thickness subject to external pressure (in German), *Z. Flugwiss.* **9,** 4/5, 143–150, Apr./May 1961.

The calculation of the initial buckling pressure of closed circular cylindrical shells with multiply graded wall thickness is proposed as follows:

The cylinder is replaced by an "ideal" one with only one or two mean thicknesses and the critical pressure is determined according to linear theory of Donnell and Biezeno-Koch with the aid of transfer matrices. Authors prove on the basis of a series of American theoretical and experimental researches that the nonlinear theory of finite deflections does not offer satisfactory improvement. Therefore they recommend to use the results of linear theory, however with a reduction factor 0.6–0.8 according to the inevitable unroundness in the construction.

Reviewer believes only a statistical appreciation of the effect of initial imperfections by means of nonlinear theory may give correct explanation of the dispersion in experimental results.

[See Bolotin, V. V., AMR **13**(1960), Rev. 2220.]

I. Hlavacek, Czechoslovakia

6594. Singer, J., Buckling of thin circular conical shells subjected to axisymmetrical temperature distributions, *Bull. Res. Council Israel* **9**C, 1/2, 49–50, Feb. 1961.

6595. Lunchick, M. E., Plastic axisymmetric buckling of ring-stiffened cylindrical shells fabricated from strain-hardening materials and subjected to external hydrostatic pressure, David W. Taylor Mod. Bas. Rep. 1393, 32 pp., Jan. 1961.

Author derives inelastic buckling stress of short circular bands of uniform thickness; not inelastic general instability of a ring stiffened cylinder as could be construed from the title. Instantaneous values of Poisson's ratio are used instead of the plastic value as was done by Gerard [Gerard, G., "Plastic stability theory

of thin shells," *J. Aero. Sci.* **24**, no. 4, Apr. 1957; AMR **11**(1958), Rev. 2537]. Lunchick reports his theoretical buckling stresses for long cylinders in axial compression are less than 2 percent smaller than Gerard's. H. Becker, USA

6596. Lunchick, M. E., Graphical methods for determining the plastic shell-buckling pressures of ring-stiffened cylinders subjected to external hydrostatic pressure, David W. Taylor Mod. Basin Rep. 1437, 23 pp., Mar. 1961.

Charts are presented for calculations of inelastic buckling in short circular bands under external pressure, based on the axisymmetric theory of preceding review and lobar buckling theory of Reynolds [Reynolds, T. E., "Inelastic lobar buckling of cylindrical shells under external hydrostatic pressure," DTMB Rep. 1392, Aug. 1960]. Data are included for both the lobar and axisymmetric modes in shells in which Young's modulus = 30×10^6 psi and elastic Poisson's ratio = 0.3. H. Becker, USA

6597. Lunchick, M. E., Plastic prebuckling stresses for ring-stiffened cylindrical shells under external pressure, David W. Taylor Mod. Basin Rep. 1448, 17 pp., Jan. 1961.

As a prelude to computing inelastic buckling in the shell wall of a ring-stiffened cylinder, author indicates a need to determine the prebuckling inelastic stress distribution.

This report depicts the author's method, in which deformation plasticity is used. It is an extension of the elastic theory of Salerno and Pulos [Salerno, V. L., and Pulos, J. G., "Stress distribution in a circular cylindrical shell under hydrostatic pressure," PIBAL Report 171-A, 1955]. H. Becker, USA

6598. Grigolyuk, E. I., Stability of spherical shells with finite deflections and unsymmetric deformations (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 68-73, Nov./Dec. 1960.

6599. Cetmeli, E., Stability of circular cylindrical shell of constant wall thickness under the influence of symmetrical radial pressure (in German), *Bul. Istanbul Tekn. Univ.* **13**, 1, 33-43, 1960.

Initial buckling pressures of open circular cylindrical shells are developed on the basis of linear Wansleben's theory [Girkmann: Flächentragwerke, 1946, Chap. XXI].

The results for central angles 45°, 60°, 90°, 120°, 180° and for hinged supports of all edges are shown in graphs.

Reviewer believes, however, that this method is valid with regard to the supposed edge conditions only in the case of interior fields of orthogonal stiffened cylinders.

The modern conception of stability would require also an investigation from the standpoint of finite deflections and initial imperfections, because the real carrying capacity of the shell is remarkably lower than the initial buckling load.

I. Hlavacek, Czechoslovakia

6600. Lackman, L., and Penzien, J., Buckling of circular cones under axial compression, *ASME Trans.* **81** E (*J. Appl. Mech.*), 3, 458-460, Sept. 1960.

It is demonstrated that the theoretical elastic buckling load for an initially perfect, right circular truncated cone under axial compression is equal to $P_{cyl} \cos^2 \alpha$, where P_{cyl} is the critical load for a right circular cylinder of the same thickness and α is the semivertex angle of the cone.

Tests were made on cones fabricated by electroplating pure nickel on steel mandrels. Experimental compressive buckling strengths agreed well with calculated values when the calculated values were corrected to account for the effect of initial imperfections. The correction factors developed for right circular cylinders by Donnell and Wan and by Batdorf, Schildcrout and Stein were found to apply to cones, the correction factor for a given cone being the same as the correction factor for a cylinder whose ratio of radius to thickness, r/t, was the same as the ratio $R/(t \cos \alpha)$ for the cone, where R is the maximum radius of the cone.

J. W. Clark, USA

6601. Szilagyi, L., and Michelberger, P., An approximation method of calculating the stability of thin-walled elliptical tubes (in German), *ZVDI* **102**, 26, 1235-1238, Sept. 1960.

Stresses and (finite) deflections in elliptical tubes subjected to internal or external pressure are determined assuming that the midline of cross sections (a) maintains its length unchanged and (b) remains elliptical. Let x_0 be the initial axis ratio; for $x_0 < 0.73$ the external pressure is found to flatten the tube gradually, while for $0.73 < x_0 < 1$ the tube snaps through under a critical pressure.

In reviewer's opinion, the fact that the equilibrium conditions written at end points of both axes yield widely different results indicates that approximation (b) is rather coarse.

P. Cicala, Italy

6602. Korotkin, Ya. I., and Maksimadzhi, A. I., Equations for verifying the local stability of corrugated bulkheads (in Russian), *Sudostroenie* no. 4, 9-12, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7974.

Expressions are set up for verifying the local stability of corrugated bulkheads, formed of circularly-cylindrical plates, and loaded by a uniformly-distributed pressure. These formulas have been set up on the assumption that the individual corrugations, fairly remote from the supporting edge parallel to their (common) generating line, act in bending as a similarly loaded beam, constrained at the edges.

By separating from the individual corrugation, by means of two transverse sections, an elementary beam-strip of unit width, and investigating the corresponding conditions of equilibrium, expressions are obtained for the catenary and bending stresses, acting in the median sections of the peak and the hollow of the corrugation; for the determination of the bending stresses in the median sections of the peak and the hollow of the corrugation; and for the determination of the bending stresses in the median section corresponding with the inflexion point of the corrugation.

The resulting analytical formulas are used to construct tables of nondimensional coefficients, enabling the determination of the aforesaid stress values for some particular values of the angles of conjugation of the circular arcs of the corrugation(s), for any given relationship of the radius of the circular arcs forming such a corrugation, the thickness thereof, and the predetermined pressure.

These tables have enabled it to be determined that the catenary stresses in the median planes of the peaks and hollows of the corrugation are little related to the angle of conjugation; and that this angle materially influences the bending moments in the median sections, correspondingly, of the peaks, hollows, and points of flexure of the corrugations.

The expressions which have been set up can also be used to verify the local stability, not only in the case of vertically-arranged corrugations, when the transverse load on the corrugations is constant, but also for horizontally-arranged corrugations, considering that, in such case, the pressure drop will also be small compared with the calculated value of the pressure head, as considered in practice. B. I. Slepov

Courtesy Referativnyi Zhurnal, USSR

6603. Golitsynskaya, E. D., Certain problems in the stability of thin cylindrical shells (in Russian), *Inzhener. Sbornik Akad. Nauk SSSR* **25**, 145-153, 1959.

6604. Chapman, J. C., Erickson, B., and Hoff, N. J., A theoretical and experimental investigation of creep buckling, *Inter. J. Mech. Sci.* **1,** 2/3, 145–174, Apr. 1960.

Paper describes an approximate graphical and numerical procedure for the determination of the collapse time of initially curved columns subject to creep. A "critical deflection" is found at which the bending rigidity is so reduced that the column becomes unstable. The analysis is carried out on the assumption that the actual column can be replaced by an idealized two-flange column which deflects sinusoidally up to failure. The flexural stiffness is taken as constant along the length of the column and equal to the mid-point stiffness, which is determined from the stress-strain curve of the material. The corresponding "critical time" is then calculated by using the creep-strain versus time curves of the material. The method appears to be in agreement with experimental results. From authors' summary by G. Gerard, USA

6605. Goschy, B., Using the ultimate strength theory in design—Eccentrically-loaded rectangular concrete columns, *Civ. Engng., Lond.* **56,** 656, 348–350, Mar. 1961.

Very approximate theory for the ultimate load of unreinforced columns is given, but no experimental justification is presented.

L. H. Mitchell, Australia

Vibrations of Solids

(See also Revs. 6482, 6512, 6644, 6669, 6844, 6867, 6901, 6930, 6999, 7000, 7002, 7003)

6606. Milne, R. D., The steady-state response of continuous dissipative systems with small non-linearity: Parts 1 and 2, *Quart. J. Mech. Appl. Math.* **14,** 2, 229–256, May 1961.

A formal procedure for obtaining the small displacements of a steadily oscillating nonlinearly elastic body under load is outlined. Doubly-valued relations between stress and strain, such as in hysteresis loops, are readily handled. Displacements are represented by harmonic series in the time. The small nonlinearities weakly couple the equations for the separate frequencies. Resonance frequencies introduce strong coupling. Numerical solutions for a riveted rod in torsion and bending are exhibited. This nonlinear system has two formal solutions only one of which is experimentally observed. Need for investigation of the stability of the solutions is pointed out. C. M. Ablow, USA

6607. Shaman'ski, B. E., and Shevebo, V. M., The equations of vibration of a filament or rope of variable length (in Ukrainian), *Dopovidi Akad. Nauk URSR* no. 5, 498-501, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7245.

A system of equations suggested by G. N. Savine's analysis for the dynamics of a ponderable, inelastic filament or rope of variable length, the solution whereof is sought in the form

$$u(x,t) = \left(Q + \frac{qx}{2}\right)\frac{x}{Kg}\,\Phi(t)$$

For the determination of the $\Phi(t)$ function by the Bubnov-Galerkin method, an inhomogeneous, common, second-order differential equation with variable coefficients is derived. For the case of a trapezoidal hoisting tachogram, the problem is reduced to the intergration of a homogeneous equation.

A criterion is derived for the damping of the forces in a ponderable, viscoelastic filament of variable length during hoisting and lowering of a load suspended therefrom.

M. E. Temchenko
Courtesy Referativnyi Zhurnal, USSR

6608. Taleb, N. J., and Suppiger, E. W., Vibration of stepped beams, *J. Aerospace Sci.* **28,** 4, 295–298, Apr. 1961.

A relatively simple method of determining the natural frequencies of beams in lateral vibration is presented based upon an integral equation technique which makes use of the Cauchy function method. Fundamental frequency and mode for a simply supported stepped beam are calculated and compared with exact results; comparison is very good.

The method will prove useful in certain beam vibration problems when digital computers are not available.

J. L. Bogdanoff, USA

6609. Boyce, W. E., and Handelman, G. H., Vibrations of rotating beams with tip mass, AFOSR TN 60-1402 (Rensselaer Polytech. Inst., Math. Dept. Rep. 39), 32 pp. + figs., Nov. 1960.

Report deals with transverse vibrations, emphasis being on second and higher modes. For high rotational speeds and general section properties, authors conclude that frequency of fundamental mode decreases with increase in tip mass [see also AMR **12**(1959), Rev. 1785]. Frequencies of high enough modes, however, increase with increase in tip mass. For a uniform beam, statement applies even to second mode. Authors use an asymptotic (or singular) perturbation method. J. C. Burgess, USA

6610. Chu, H.-N., Influence of transverse shear on nonlinear vibrations of sandwich beams with honeycomb cores, *J. Aerospace Sci.* **28,** 5, 405–410, May 1961.

The transverse shear deformation included in the title problem is that of the core, while the nonlinearity is due to the geometry of moderately large deflections, e.g., $e_x = \partial u/\partial x + (\partial w/\partial x)^2/2$. Stress equations of motion are given which were derived, using Hamilton's principle, in a more detailed work by the author. The displacement equations of motion are derived neglecting stresses in the thickness and width directions. A solution for free flexural vibrations with hinged ends is obtained by assuming one loop of a sine wave for lateral deflection with a cosine loop resulting for the shear deflection. Two equations result for the time variation, each with a cubic "hardening spring" term. Amplitude ratios are found by equating coefficients of the linear restoring terms and it is shown by example that for the parameters of typical aircraft sandwich construction, the resulting coefficients of the cubic terms are approximately equal. Also, for cores with a much smaller Young's modulus than that of the faces, the ratio of linear to nonlinear period is the same whether or not shear deformations are included. Author concludes that, as for linear vibrations, the influence of transverse shear deformation for common aircraft construction can be neglected. Notation after inserting assumed deflections is poor and, in places, misleading, but most of the paper is well organized. H. E. Lindberg, USA

6611. Lachassagne, J., Whirling of rotating shafts (in French), *Bull. Assn. Tech. Marit. Aero.* no. 60, 577–597, 1960.

Author describes some of the problems arising in the system of a crankshaft coupled with a naval propeller, and enters into the details of the problem of the forced vibrations of such a system caused by the propeller impulses. System is considered to be composed of a disk (representing the propeller) attached to a massless elastic shaft; the center of the disk may displace itself in its plane, and, moreover, its axis of revolution may undergo an angular deviation from its original position. The horizontal elastic restoring force which the shaft exerts on the disk is supposed to be unequal to the vertical elastic restoring force, and the same applies to the elastic restoring moments. Because of the gyroscopic effects of the disks the horizontal and the vertical vibrations are coupled, and the number of degrees of freedom is equal to four.

Article may be considered as an extension of the publication on the whirling problem by den Hartog [AMR **10**(1957), Rev. 27], who investigated only the free vibrations, and supposed the elastic restoring forces and moments to be independent of their direction. Author seems to be unaware of that publication. His article is somewhat difficult to read, because he mentions only the most important parts of the calculations.

A. D. DePater, Holland

6612. Filekin, V. P., The free, nonlinear oscillations of a beam with external and internal resisting moments (in Russian), *Trudī Kuibyshevsk. Aviats. In-ta* no. 6, 87–89, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8011.

A solution is given for the nonlinear differential equation of the free oscillations of a beam with internal and external resisting moments. The resisting forces are assumed to be applied to the beam in the form of a distributed load, expressed by a small parameter and a particular function of the rate of oscillation of a selected point of the beam.

The differential equation is solved by Bogolyubov and Krylov's asymptotic method [N. N. Bogolyubov, Iu. A. Mitropol'skiy: "Asymptotic methods in the theory of nonlinear oscillations," Moscow, 1955]. The solution is found in the form of an exponential expression by powers of the small parameter.

M. I. Alyamovskii
Courtesy Referativnyi Zhurnal, USSR

6613. Chang, C. C., and Fang, B. T., Transient and periodic response of a loaded sandwich panel, *J. Aerospace Sci.* **28,** 5, 382–396, May 1961.

Authors investigate influence of shearing deformation and rotational inertia on the flexural vibrations of a rectangular sandwich panel. Damping is introduced by assuming viscous resistance of the sandwich core to shearing deformation.

Equations of motion (summation convention is here used in a somewhat confusing manner) are solved by Fourier series expansion and Laplace transform, assuming a unit step excitation. It is found that the influence of shearing deformation and rotational inertia can be essentially characterized by two parameters. In contrast to the usual analysis three families of different modal shapes are possible for each nodal pattern of the panel. The first is predominantly flexural. The other two are predominantly shear. Some limiting cases are discussed.

H. Parkus, Austria

6614. Pashchevski, D. P., The approximate determination of the frequencies of natural vibration of ribbed slabs resting on an elastic foundation (semi-space) (in Russian), Mosk. Arkhitekt. In-ta, Moscow, 1958, 29 pp. + illus; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8017.

For the title problem, the calculation uses direct, variational methods and is founded on the properties of the potential energy of an elastic body in the extreme, and the law of conservation of energy. The essence of the method of calculation is as follows: It is assumed that the oscillations of the slab can be represented by superposition of a series of its own natural vibrations. The eigenfunctions are represented by functions satisfying the equation of the bending vibrations of a homogeneous, hinge-supported slab; i.e., it is assumed that these functions may be identically approximated to the eigenfunctions of a ribbed plate resting on an elastic foundation. It is further assumed that the series in question contains terms determining the displacements of a vibrating plate approximating to an absolutely solid body. The known equation of the potential bending energy of a homogeneous plate is used to calculate the potential bending energy of the slab in question. A particular method of approximation is used to determine the reaction of the elastic foundation to the oscillations of the slab, and the potential strain (deformation) energy of the foundation associated with this reaction is calculated. The kinetic energy of the oscillations of the slab is calculated. In determining the kinetic energy of the system, only the mass of the oscillating slab, assumed to be of uniform thickness, is taken into account. From the condition of equality of the maximum values of the kinetic and potential energies of the system, and the requirement of minimum vibrational frequency (variational condition) an infinite system of differential equations is obtained, determining the natural frequencies. In his solution, the author limits himself to three of these equations.

L. M. Lyamshev
Courtesy Referativnyi Zhurnal, USSR

6615. Priebs, R., A simple method of formulating the frequency equation of a torsionally oscillating system, free at both ends (in German), *Ing.-Arch.* **30,** 2, 141–147, Feb. 1961.

Recursion relations are developed which greatly simplify the numerical computation of the coefficients in the frequency equation of a torsional system with free ends. With the coefficients thus known, the equation can then be solved for the natural frequencies by means of the Homer-Newton method. A numerical example is presented, and the method is compared with the closely related procedure of W. A. Tuplin.

According to the author, the principal advantage of his method over Tuplin's is that the amplitudes of the moments or displacements as explicit functions of frequency are directly determined in the course of computing the frequency equation coefficients. Furthermore, although the number of calculation steps is about the same, Tuplin's procedure is somewhat more complicated and time consuming.

D. A. Conrad, USA

6616. Balogh, A., On some features of the characteristic equation of torsion oscillations (in German), *Acta Techn. Acad. Sci. Hungaricae, Budapest* **32,** 3/4, 429–440, 1961.

Author considers the characteristic equation belonging to the differential equations for the angular displacements of a set of masses attached to an elastic shaft, and indicates how the coefficients of the various powers of w^2—w being the radial frequency—may be calculated systematically.

Reviewer considers the value of this publication questionable. In such calculations one should start from the equations for the moments in the parts of the shaft rather than from the equations for the angles of the masses; more preferable is Holzer's methods, but when a digital computer is available, the problem should be reduced to that of determining the characteristic values of the corresponding matrix.

Article is difficult to read and contains a number of calculation errors, e.g. in the deduction of Eq. [3]. Equation [1] is satisfied by $w = 0$, as it should be; however, the coefficient of w^0 of the characteristic equation in its ultimate form is unequal to zero.

A. D. DePater, Holland

6617. Kramer, E., Electronic computation of the torsional vibration of ship propulsion systems (in German), *ZVDI* **102,** 32, 1519–1525, Nov. 1960.

A Holzer-type procedure is used for the computation of the damped frequency response and of the undamped natural frequencies and mode shapes of single- and multiple-branch systems. The frequency response calculation requires the solution of $2n$ (n = number of branches) simultaneous equations for the real and imaginary parts of the end displacements. The natural frequency computation closely follows the Holzer-Tolle procedure.

The system was programmed for a Siemens 2002 electronic digital computer, and the results of a three-branch example are presented, along with discussion of computing time and input/output quantities. The program itself is not presented.

Procedures for determining appropriate values of damping constants and exciting moments are also indicated.

D. A. Conrad, Germany

6618. Blinnik, S. I., Calculations for the natural vibrations of a four-column press (in Russian), Raschetyi na Prochnost' v Mashinostr. (MVTU **89**), Moscow, 210–225, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11288.

A procedure is given for the determination of the lowest frequency of the natural vibrations of a four-column press. The higher harmonics of the system are not investigated, because the frequency of the disturbing force, determinable by the number of operations of the movable cross piece, appears to be relatively small and can only be compared with the lowest frequency of the press vibrations. For calculating the lowest frequency of the vibrations Dunkerley's method is used; in conformity with that method the multimass system is broken up into a number of particular systems with one or two steps of freedom in each. Separate investigations of the frequencies of the linear and angular vibrations are carried out for the architrave, the movable cross piece, the foundations and the columns. To start with, the statistical indeterminability of the system was found, followed by the determination of the corresponding transpositions without taking into account the elasticity of the base, Vereshelagin's principle being followed. Supplementary transpositions due to the shift of the lower block lying on an elastic base are then calculated and the lowest partial frequencies of the particular system and the lowest principal frequency of the vibration of the press are found. If the frequency of the disturbing force is found to be close to the lowest frequency of the natural vibrations of the press at the parameters assigned to it then it is possible with the aid of the relations obtained to vary the weight of the constructional components and the dimensions of the foundation respectively.

A. A. Gusarov

Courtesy Referativnyi Zhurnal, USSR

6619. Kononenko, V. O., The resonance properties of a centrifugal vibrator (in Russian), *Trudi In-ta Mashinoved. Akad. Nauk SSSR, Seminar po Teorii Masbin i Mekbanizmov* **18**, 71, 22–42, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11289.

The forced vibrations of a vibrator are investigated; the vibrator consists of one or two rotating, eccentrically disposed masses, a centrally disposed mass of the motor and springs. A new feature here appears to be the consideration of the linkage of the velocity of rotation of the rotor of the motor with the rotation of the eccentric masses. The author makes a general investigation of the system of equations for the motion into which enter not only the equations for the motion of the vibrator itself but also the equation for the rotational motion of the rotor; the linkage between these equations is explained by the relation of the moment transmitted by the motor to the velocity of rotation which, strictly speaking, is not constant. The system of equations possesses a small degree of nonlinearity; because of this the system is solved on the assumption that the motion is close to being harmonic. Steady state expressions are obtained for the amplitude, the velocity of rotation and the moment transmitted by the motor. The stationary solution corresponds geometrically to the point of intersection of a special curve (of the type of a resonance curve) characterizing a system, with a curve, representing the motor's characteristic. The investigation of the stability enabled a determination to be made in regard to which of the points of intersection correspond with a stable steady state and which with an unstable one. The theoretical substance was indicated of the phenomenon, observed during the slow transition of resonance, comprising the impossibility of disclosing by experimental means the points on the descending (posterior) branch of the resonance curve on dispersion and the points on the same branch and on part of the ascending branch—on running out. The theoretical investigation also offered an explanation for the effect of a sharp increase of velocity after passing through the resonance zone. Examination of the energy correlations enabled a theoretical substantiation to be put forward for the known "Sommerfeld effect", which is expressed by difficulty in going through resonance by a system, the motor of which is under-powered.

F. M. Dimentberg

Courtesy Referativnyi Zhurnal, USSR

6620. Catling, H., Stick-slip friction as a cause of torsional vibration in textile drafting rollers, *Proc. Instn. Mech. Engrs*, **174,** 17, 575–586, 1960.

6621. Khronin, D. V., The conjoint vibrations of the discs, shafts and blades of the rotors of turbo-compressors, and their critical running speeds (in Russian), *Izv. Vyssb. Ucbebn. Zavedenii: Aviats. Tekbn.* no. 1, 171–178, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 8167.

An investigation of the coupled vibrations of the shafts, disks and blades of the rotor of a turbo-compressor machine (turbo-blower).

The stresses in the rotating disk are investigated, it being assumed that its internal contour is rigidly connected with the shaft; on the circumference of the external periphery, the influence of the blades is taken into consideration by equating the bending moments and shearing forces on the periphery of the disk to the linear moments and forces set up by the blades, which are expressed in terms of their dynamic rigidity.

Integration of the differential equation for the bending of a rotating disk under given boundary conditions enables the moment of the disk acting on the shaft to be calculated, and hence, the dynamic rigidity of the disk, allowing for the influence of the blades. An equation is also obtained for finding the critical running speed of the disk.

Further, the critical running speeds of a rotor in relation to the vibrations of the disks and the rotors are determined. A corresponding characteristic equation is given for the case of a rotor with two disks.

Ya. S. Uflyand

Courtesy Referativnyi Zhurnal, USSR

6622. Ezzat, A., Damping characteristics of pipes vibrating in flexure and filled with various materials, *Exper. Mech.* **1,** 7, 10–15, July 1961.

An experimental investigation is described in which a pipe was filled with various materials, both liquid and granular, and excited sinusoidally by an electromagnetic shaker. Results indicate an increase in damping with increase in viscosity of contained liquids and decrease in particle size of contained granular materials.

G. Isakson, USA

6623. Katz, L., Mathematical analysis and digital computer solution of natural frequencies and normal modes of vibration for a compound isolation mounting system, David W. Taylor Mod. Basin Rep. 1480, 16 pp., Jan. 1961.

The matrix solution suitable for digital computation is set up for a compound isolation mounting consisting of an assembly (treated as a rigid body) supported by a set of isolation mountings which are carried by a cradle also supported on a second set of isolation mountings. Damping is not considered. Twelve homogeneous, simultaneous equations are involved and a solution for the eigenvalues and eigenvectors has been programmed for an IBM 704 computer. No results or comparison with practice or other work is given. The program can be used by others on application to the Applied Mathematics Laboratory, D.T.M.B.

P. Grootenhuis, England

6624. Gorchakov, M. G., The electrical simulation of the oscillations of elastic systems with nonlinear damping (in Ukrainian), *Prikl. Mekh.* **4**, 2, 205–210, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7260.

The application is discussed of an electrical analog method, and an equipment is described for determining the induced oscillations of mechanical systems with nonlinear damping. An example is given of a problem solved with this equipment: determining the induced vibrations of a motorcycle and sidecar for the case of a shock-absorber with a nonlinear characteristic.

M. E. Temchenko
Courtesy Referativnyi Zhurnal, USSR

6625. Hoff, N. J., Damping of the vibrations of a coiled spring due to creep, AFOSR TN 60-833 (Stanford Univ., Dept. Aero. Engng. Rep. 96), 30 pp. + charts, June 1960.

6626. Parry, F. W., A simplified procedure for solving natural frequencies of multiple-mass systems, *Mach. Design* **33**, 9, 121–125, Apr. 1961.

6627. Cernohorsky, J., Contribution to determination of natural frequencies of system with two degrees of freedom (in Czech.), *Zpravodaj Vzlu* **1** (25), 17–19, Mar. 1961.

This paper presents a graphical solution of dynamic relations of two-mass system enabling a quick orientation and calculation. The nomograms relate even to the torsional system provided that the mass will be replaced by inertia moment, the spring constant by torsional stiffness and the partial frequency of translation vibration by natural frequencies of torsional vibration.

From author's summary

6628. Lundgren, T. S., Chang, C. C., and Whang, Y. C., Damping of rectangular plate vibrations, WADC TR 59-544, 20 pp., Mar. 1960.

6629. Trapp, W. J., and Lazan, B. J., Role of structural damping in acoustical fatigue, WADC TR 59-304, 26 pp., Jan. 1960.

6630. Crandall, S. H., Random vibration of systems with nonlinear restoring forces, AFOSR 708 (Mass. Inst. Technol.), 15 pp., June 1961.

6631. Crandall, S. H., Random vibration of a nonlinear system with a set-up spring, AFOSR 709 (Mass. Inst. Technol.), 22 pp. + figures, June 1961.

6632. Streda, I., Measurement of mechanical oscillations by means of accelerometers (in Czech.), *Zpravodaj Vzlu* **1** (25), 11–15, Mar. 1961.

A brief description is given of methods used for measurement of mechanical oscillation by means of pick-ups of different types. Advantages of accelerometers used for oscillation measurement are discussed at large. Besides the principal relations from the accelerometric theory, special attention is paid to the selection of most convenient principal parameters of the accelerometer, especially to the influence of the magnitude of the coefficient of damping on the frequency range of the accelerometer. Briefly the choice of the electrical principle, used in the described AG-05 accelerometer is discussed. In conclusion main technical parameters of the AG-05 accelerometer, which is a part of the measuring system designed for the measurement of aircraft oscillations, are given.

From author's summary

Wave Motion and Impact in Solids

(See also Revs. 6518, 6669, 6685, 6998, 6999, 7000, 7001, 7002, 7028)

6633. Morley, L. S. D., Elastic waves in a naturally curved rod, *Quart. J. Mech. Appl. Math.* **14**, 2, 155–172, May 1961.

Author considers the propagation of free elastic waves of small amplitude in a naturally curved rod where the neutral axis forms a plane curve of constant radius. The effects of rotatory inertia and radial shear are included, in the same way as in Timoshenko's theory for straight rods, as well as the effect of the extension of the neutral axis.

When the curvature is slight, there are considerable simplifications and a Timoshenko-type equation is obtained which governs the flexural motion. A simple relationship is then found with the phase velocity of flexural waves in the straight rod. This means that data already available for straight rods are now readily applicable to slightly curved rods of the same material and cross section.

From author's summary by E. J. Scott, USA

6634. Kurlandzki, J., On certain plane diffraction and reflection problems of elastic waves (in English), Proceedings of Vibration Problems (Polska Akad. Nauk, Inst. Podstawowyck Problemow Techniki) no. 3, 35–31, 1960.

Paper consists of two parts. In the first part, the author considers the problem of diffraction of an elastic wave about a circular hole reinforced by a ring. In the nonsteady case the Laplace transform is used to determine the transformed equations, but since the complicated inverse transform can be obtained only approximately, the author does not treat this case. In the steady case a complete treatment by the Laplace transform is given.

In the second part, the problem of reflection by a wedge is solved by using a finite Fourier transform.

E. J. Scott, USA

6635. Kumar, S., Some further studies on scabbing in materials, Proceedings of the Fifth Congress on Theoretical and Applied Mechanics, Univ. of Roorkee, Roorkee, India, Dec. 23–26, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., C. 27–C. 40.

Paper is part of a series and due to the references to previous and future papers not easy to read in itself.

When a compressive shock wave reflects at a free boundary of a solid object, the reflected stresses are tensile. When the material is stronger in compression than in tension, fractures may occur due to the reflected tensile stress wave.

Author develops a new theory for scabbing, called contour method, and compares it with two previously developed methods, viz. the intercept and the stress jump method. The new theory gives a better agreement with experimental results, obtained by the use of bars made from plaster of Paris.

R. G. Boiten, Holland

6636. Jones, O., and Ellis, A. T., A theoretical study of longitudinal strain pulse propagation in wide rectangular bars, Calif. Inst. Tech., Hydrodyn. Lab. Rep. E-108.14, 33 pp., Apr. 1961.

6637. Barton, C. S., and Volterra, E. G., On the elastic impact of short cylindrical rods on long cylindrical rods, Proc. 4th Midwest Conf. Solid Mech.; Austin, Texas, Univ. Press, Sept. 1959, 318–330.

6638. Vodicka, V., Elastic waves in an infinite medium in the case of plane strain, *Appl. Scient. Res.* (*A*) **10**, 3/4, 235–240, 1961.

Using Fourier transforms author solves dynamical problem of infinite medium in the case of plane strain. Body forces dependent on both time and in-plane coordinates are included in analysis. Method used is an extension of that given by I. N. Sneddon ["Fourier transforms," McGraw Hill Book Co., pp. 400-402, 1951] for solution of the static problem. No illustrative examples are presented.

S. J. Citron, USA

6639. Dunkin, J. W., and Eringen, A. C., Reflection of elastic waves from the wavy boundary of a half-space, Purdue Univ., School Aero. Engng. Sci. TR 17, 53 pp., Oct. 1960.

6640. Basil'ev, Yu. I., Some inquiries on the analysis of coefficients of reflected and refracted elastic waves (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk SSSR* no. 6 (173), 52-80, 1959.

6641. Keller, F., Measurement of the energy distribution of longitudinal and flexural waves in plates under noise excitation (in German), *Acustica* **10,** 5/6, 349-356, 1960.

Two velocity-sensitive vibration pickups were used on opposite sides of plate (thickness small compared to wavelength). Pickups were matched for sensitivity and phase over range 100 to 5000 cps. Sum and difference of electrical outputs separated particle velocities for each wave type. Mechanical impedance was measured as function of frequency, and energy computed for each wave. Below first two extensional resonances, flexural energy exceeds extensional by about 10 to 30 db, depending on material. At high frequencies, extensional energy eventually dominates by about 10 db. Results are important for sound isolation of walls.

V. Salmon, USA

6642. Perzyna, P., General analysis of the problem of propagation of plane elastic-plastic waves in a nonhomogeneous medium (in English), *Arch. Mech. Stos.* **12,** 3, 371-378, 1960.

Author sets out to analyze propagation of plane strain waves in nonhomogeneous elastic-plastic medium assuming a second-order relation between strain and displacement. Main concern is with investigation of strain waves in soil and author neglects transverse motions. Analysis is used to give conditions necessary on form of $\sigma - \varepsilon$ relation and mechanical properties of medium to obtain solutions. Discontinuities on both elastic and plastic waves are also considered; cause is ascribed to definite boundary conditions in case of linearized $\sigma - \varepsilon$ relation.

After stating problem author simplifies by assuming bi-linear stress-strain relation, with a break at the yield point, before attempting solution. Mathematics employed assumes familiarity with method of characteristics.

No examples are given of applications of work and there are no references to papers other than by author.

Reviewer finds statement that work on propagation of elastic-plastic waves has so far been based on assumption that strains are infinitely small somewhat surprising.

J. M. Bowsher, England

6643. Nikitin, L. V., Propagation of transverse elasto-visco-plastic waves in beams and plates (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **30,** 31-46, 1960.

A study has been carried out of transversal wave propagation in beams and plates of elasto-visco-plastic material including rotatory inertia and shearing effects. The stress, deformation and force fields at any place during wave propagation have been determined exactly, using ordinary equilibrium conditions, satisfying elasto-visco-plastic properties of material under consideration.

M. M. Stanisic, USA

6644. Jerabek, J., Impact on structures (in German), *Dtsch. Eisenbahntech.* **8,** 8, 405-412, Aug. 1960.

Article deals with some specific cases of vibrations caused by impact (as distinct from those caused by variable forces). In the first instance, author deals with elastic systems having one degree of freedom subjected to impact acting with a frequency equal to the natural frequency of the system (or its multiples), i.e. $n_0 = k n_r$ ($k = 1, 2, 3\ldots$), where n_0 = natural frequency, n_r = impact frequency. The solution is obtained for undamped vibrations only.

The second part of the article deals with the "Re-bound" method (Rückschlag - Methode) developed by the author in order to investigate propagation of impact waves in structures.

The method consists essentially of equal metal balls being suspended on strings and touching lightly the surface of the model. When the latter is subjected to impact the balls bounce to a height depending on the impact intensity. A photo of the ball-pattern may be assumed to represent a true picture of the response to impact (actually there is a time lag between the balls, but this is disregarded). Mathematical derivations are used to evaluate the results of the experiment.

J. Solvey, Australia

6645. Blume, J. A., Structural dynamics in earthquake-resistant design, *Trans. Amer. Soc. Civ. Engrs.* **125,** Part 1, 1088-1139, 1960.

This very extensive paper is no doubt a milestone in engineering seismology. The following is the synopsis as presented by the author:

Research efforts utilizing high-speed digital computers and electric analogs have indicated vast differences between earthquake shear values arrived at by design and adherence to codes and for structures' actual earthquake behavior. This paper attempts to reconcile these differences, with the aid of comprehensive structural and dynamic analyses and research efforts on a traditional filler-wall-type office building and a modern glass-wall structure. Included are values for strengths, rigidities, and inelastic energy-absorption for the traditional building under various distortions up to failure. The results of a comprehensive series of analog tests for the modern 20-story structure, using four complete earthquake records with sixteen various systems of damping and rigidity values, are also included. Certain inconsistencies and pitfalls in present-day design practice are demonstrated and new considerations are suggested for resisting the occasional but extreme energy releases of nature that are involved in earthquakes.

J. Solvey, Australia

6646. Dremin, A. N., and Karpukhin, I. A., Method for determination of shocks in adiabatic, dispersive substances (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **3,** 184-188, 1960.

The proposed method for measuring shock adiabates in strongly nonuniform solids consists in measuring first the shock front velocity in a known uniform medium by electrical devices and then repeating the measurement with a combination of two disks of the known medium and of the unknown dispersive medium. For illustrating the method measurements have been undertaken with varying mixtures of paraffine with marble and paraffine with quartz.

W. Wuest, Germany

6647. Kaliski, S., On a concept of basic solutions for orthotropic elastic and anelastic bodies (in English), *Arch. Mech. Stos.* **11,** 1, 45-60, 1959.

This paper gives the classical solution for the problem of the propagation of a disturbance in an *infinite* orthotropic medium, first in the hypothesis of elasticity, then in the case of anelasticity of the Boltzmann linear type.

It is presented by the author as a "basic" solution of the boundary problem for anisotropic anelastic bodies of finite size; the validity of this solution is restricted in time to $t < C'$, this

limit being defined by the time necessary for the disturbance to reach the boundary.

The solution is given implicitly along quite classical lines for a rectilinear orthotropic medium, using Fourier's methods in space and Laplace transformation in time. As reviewer understands it, author's upper limit C' should depend on the smallest time necessary for the elastic wave front to reach the largest inner parallelepiped inclosed by the given boundary, starting from the smallest parallelepiped which wholly contains the region of perturbance.

Obvious extensions to cylindrical and spherical orthotropy, using the corresponding coordinates, are mentionned by the author, boundary conditions being established in such a manner that separation of variables and expansion in terms of eigenfunctions are possible. F. Buckens, Belgium

6648. Berzon, I. S., Determination of spectral coefficients of reflected longitudinal waves coming from a thin layer (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk SSSR* no. 6 (173), 163–186, 1959.

6649. Zorowski, C. F., Shock-damping calculations, *Mach. Design* **33,** 11, 155–159, May 1961.

Soil Mechanics: Fundamental

(See also Revs. 6468, 6642, 6707, 7001)

Book—6650. Brinch Hansen, J., and Lundgren, H., Fundamental problems in soil mechanics [Hauptprobleme der Bodenmechanik], Berlin, Springer-Verlag, 1960, xii + 282 pp. DM 36.

The book of the two professors of the Technical University of Copenhagen consists of five main chapters. Prof. Lundgren, in the first four chapters, gives first, in somewhat condensed form, an outline of fundamental ideas and of the main soil properties. Chapter 2 deals with field and laboratory testing, without going into detail on laboratory determination and intensive examination. The methods treated are mainly those used in Scandinavian countries. The third chapter presents the questions and theories of water movement in soils without and with volume change: problems of seepage and consolidation. Chapter 4 is devoted to deformation problems: stress distribution, computation of settlements, constructions on elastic foundations. A very valuable feature of these chapters is that they point out the inadequacies of the usual methods of computation and gives sound critical comments.

Chapter 5—from Professor Brinch Hansen—deals, in somewhat greater extent, with the stability of earth masses. The author presents, in a clear and condensed manner and from the practical viewpoint, his own general failure theory, then applies it to individual problems. The different cases of the active and passive earth pressure on different structures; application of the equilibrium method, stability of foundations; bearing capacity of spread foundations and of piles; stability of slopes, of cellular cofferdams and of anchorings are the main problems treated. Author gives ample aid for the direct application with charts and tables. The charts supplying the coefficients of the earth pressure on rigid walls turning about an arbitrary point are of the utmost importance. Reviewer feels that some remarks and allusions to other theories would be of great value.

The book is very comprehensive and gives, in a clear form, a fine picture of the most important problems in soil mechanics.
A. Kezdi, Hungary

6651. Krzyszton, D., and Rogowski, L., The results of experimental investigations of an obliquely layered stochastic medium (in English), *Bull. Acad. Polonaise Sci., Ser. Sci. Tech.* **8,** 11/12, 689–696, 1960.

An interesting paper in which the results of a theory concerning the movement of a stochastic medium are verified experimentally for the case of a medium with oblique layers. The medium used was sand which was laid in layers separated by finely sliced mica. The inclination of the layers to the horizontal could be altered by tilting the box containing the sand and the experiment consisted in measuring the vertical and horizontal displacements of the medium when a quantity of sand was removed from a slot beneath the sand.

Among other results it was found that the vertical displacement of the particles at any level was Gaussian, the maximum displacement occurring along a line inclined to the vertical passing through the slot. G. H. Lean, England

6652. Litwiniszyn, J., On a certain problem of stochastic bodies with discontinuously non-homogeneous properties (in English), *Bull. Acad. Polonaise Sci., Ser. Sci. Tech.* **7,** 12, 673–678, 1959.

Author presents a partial differential equation describing the so-called subsidence basin of an incompressible stochastic plane body in terms of two functional coefficients representing the point-variable properties of the medium. Displacements in a non-homogeneous body are analyzed by dividing into $n + 1$ vertical strips, each considered homogeneous in the horizontal direction, leading to $n + 1$ differential equations. Displacements on the boundaries of adjacent strips are equal. A basic solution is displayed which, with the boundary conditions above and the incompressibility condition, leads to a system of n Volterra integrals of the first kind for $n + 1$ unknown kernels. Author alludes to an experiment carried out with a sand box, the theoretical model being two homogeneous and isotropic stochastic media in the first and second quadrants of the semi-space $Z \geqslant 1$. Initial condition was realized by a narrow slot in the bottom of the box along a line parallel to plane $Z = 0$ $X = X_1 = 0$. Solution in this case is asymmetric in relation to $X = 0$ axis. Author claims the predicted asymmetry is experimentally verified; no details are given. Experiment also gave deviations of the elementary basin from the vertical axis through the slot; not predicted by model. W. R. Foster, USA

6653. Bogdanov, V. N., Some problems of the stability of earth masses in an embankment profile (in Russian), *Trudi Leningrad In-ta Inzh. Vodn. Transp.* no. 25, 60–66, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8060.

For analyzing the stability of earth slopes in the conditions of the two-dimensional problem, author uses the method of I. V. Yaropolski, which is as follows: The earth mass is regarded as a linearly-deformable region in which, applying the laws of the theory of elasticity, the principal stresses σ_1 and σ_3, produced by the external load and the weight of the earth respectively, are determined. From these principal stresses, applying the formula

$$\frac{\sigma_3 + c}{\sigma_1 + c} = \operatorname{tg}^2\left(\frac{\pi}{4} - \frac{\varphi_e}{2}\right)$$

where φ_e = critical angle, c = cohesion, the values of the angles φ_k are found. After plotting the lines equal to φ_e, the regions are determined in which φ_e is greater than the natural angle of friction. To eliminate the possibility of slip in these regions, the natural soil must be replaced by stone pitching or a gravel bed.

The problem of the stresses set up by the weight of the earth mass itself is solved by the well-known device of reduction to the corresponding problem of the stresses produced by an external, hydrostatic wad. In the first instance, the simplest case is examined of a semi-infinite slope with flat sides, for which a rig-

orous solution of the elastic wedge problem is available, in which one of the sides is horizontal and free from wad, while the other side is inclined at an angle α from the vertical and loaded by a hydrostatic pressure. The well-known paradox is discussed, consisting in that, for $\alpha = 90^\circ$, the horizontal normal stress σ_x and the shear stress τ_{xy} tend to infinity.

On the basis of purely speculative considerations the author arrives at the conclusion that the solution by the theory of elasticity is correct only for an acute-angled wedge. Next, the case of a slope of semicircular profile is considered. In this regard the author obtains, by quite elementary means, a rigorous solution for the problem of the stresses in a heavy (ponderable) semiplane with a semicircular cutout on the boundary. This solution, which does not appear to have been recorded in the literature, is obtained by super position on the stress condition of a corresponding semiplane with a concentrated force on its boundary (Flamend's problem) of a hydrostatic stress condition. (It should be noted that by the same means it is possible to obtain the rigorous solution for a wedge-shaped body bounded by two radii along which a hydrostatic load is applied, and a circular arc which is not loaded.) For the principal stresses, the following expressions are obtained

$$\sigma_1 = \gamma y, \quad \sigma_3 = \gamma y \left(1 - \frac{r_0^2}{x^2 + y^2}\right)$$

where γ is the mass density, r_0 the radius of the cutout. From this it follows that the stress distribution in the region of the cutout is not hydrostatic, as is sometimes assumed in calculating slopes of arbitrary form.

It must be remarked that: (1) Yaropolski's method can give only roughly approximate results, since it rests on the assumption that the presence of regions of limiting equilibrium does not produce a redistribution of the stresses in the elastic regions; (2) the author's conclusion that the above-mentioned solution of the theory of elasticity is correct only for the case of the acute-angled wedge is unfounded. Repeating the author's arguments it could be demonstrated, for instance, that at angles of opening exceeding 90°, the solution for the uniformly loaded wedge is likewise incorrect, although that solution presents no difficulties, and is generally accepted. A similar paradox in the case of a wedge acted upon by a moment applied to the apex has recently been analyzed by Sternberg and Koiter [E. Sternberg and W. T. Koiter, Amer. Soc. Mech. Engrs. Pap. no. A-15, 7 pp.]. These authors came to the conclusion that the usual solution of the theory of elasticity is correct for opening angles smaller than the critical value of 257°, at which all stress components either become zero or infinity. By analogy, it is possible to conclude that the solution for a hydrostatically-loaded wedge will be correct for all apex angles of the wedge less than 180°.

G. S. Shapiro

Courtesy Referativnyi Zhurnal, USSR

6654. Yeremenko, V. V., and Kovalenko, V. N., The relationship between the effective viscosity of pasty soils and the applied shearing stress (Uzbek), *UzSSR Fanlar Akad. Dokladlari* no. 8, 35–38, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8074.

The visco plastic properties of soils were investigated by means of a rotating instrument with cone rings [v. T. Ya. Gorazdovsky: *Zh. Tekhn. Fiz.* **20**, no. 9, 1950].

It is demonstrated that, contrary to existing conceptions, soils of a low moisture content (below the rolling limit), exhibit, in addition to the familiar effect of structural breakdown, also some degree of consolidation, i.e. an increase in effective viscosity with increasing magnitude of the applied shearing stress. The authors explain this phenomenon by the assumption that with increasing rates of deformation, rigid bonds are formed in the structural system through the action of intermediate, thin aqueous films.

N. I. Maninin

Courtesy Referativnyi Zhurnal, USSR

6655. Baydiak, B. V., and Shreiner, L. A., The influence of the stress condition and moisture content on the stability of clay soils in boreholes (in Russian), *Trudi In-ta Nefti Akad. Nauk* **11**, 240–263, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8078.

An investigation of the relationship between the contraction of the width of deep boreholes and the nature of the surrounding soils. The flow of the surrounding soil, or formation, into the borehole ultimately leads to its blocking. After the borehole has been cleared, the flow is resumed, and a new contraction takes place, which may lead to complete seizing of the drilling rig.

The paper is divided into an account of experimental investigations, and a theoretical part. Experimental tests on clays were made under uniaxial and triaxial compression. The test samples, prepared artifically and with an undisturbed structure, were cylindrical with a diameter of 25 mm and a height of 20 mm; also samples of annular form, with the same overall dimensions and a bore of 8 mm. At a shaping (moulding) pressure of 760 kg/cm^2, there was a fatigue compression strength of 18 kg/cm^2, and, under a pressure of 4600 kg/cm^2, a fatigue resistance of 420 kg/cm^2. The moisture content of the experimental samples was between 3.5 and 16.5%. In the instrument for testing the samples under triaxial compression, test pressures attained 1600 kg/cm^2.

The highest fatigue compression strength was found in the samples with ~ 6% moisture. After recalculating for the octahedral stress condition, the test results in the instrument for triaxial compression of cylindrical and annular samples were found to show experimental points lying practically on the same envelope curve, closely approximating a parabola. It is demonstrated that the constants in the equation of the parabola can be determined from the values of the yield point in the penetration of a punch, and the fatigue strength in compression. Diagrams of the corresponding press are given. With increasing moisture (water) content of a clay, its strength decreases; both in the artifically prepared samples and in those with a retained, natural structure. Comparative tests of artifically prepared clay samples and those with an undisturbed, natural structure of the same clay, with the same volume density, have shown that the corresponding, experimental points still fall on the same limiting curve.

Abstractor's Note: The analytical solutions obtained are inapplicable to the solution of practical problems, since, for determining the limiting stability conditions of soil formations adjoining a borehole, the selected point must not lie in the wall of the borehole, where the vertical, normal stresses are indeterminate, and lower than those assumed in the present analysis, but at a certain distance therefrom. Furthermore, the limiting stress condition in a point on the axis of symmetry under the punch cannot characterize the value of the yield point. Figure 1 shows that the radial stress on the wall of a dry borehole is not equal to zero, while Eq. [4] demonstrates that it should be equal to zero.

S. A. Roza

Courtesy Referativnyi Zhurnal, USSR

Soil Mechanics: Applied

(See also Revs. 6468, 6656, 6707)

6656. Rosenak, S., A review of information on the settlement of structures, *Struct. Engr.* **39**, 6, 195–202, June 1961.

Paper reviews the methods of predicting the settlement of structures on spread footings and piled foundations. It reports

settlement observations on structures and model tests. Reference is made to the stiffness of the structure and its effect on settlement. The limits of permissible settlement to prevent cracking or damage are discussed. From author's summary

6657. Fagnoul, A., Contribution to the study of the stability of slopes (in French), *Bull. Centre d'Etudes, Recb. d'Essais Scient. Genie Civ., Liege* **10**, 89–267, 1959.

For a material obeying Coulomb's law of strength, author uses Rankine's limiting conditions to determine critical depths beneath a slope for various chosen inclinations of the rupture surface. A series of tangential parabolae is then used to obtain a unique rupture surface conforming at the critical points with the principles of soil mechanics. Trial and error is not needed.

Reviewer believes factor of safety, defined as ratio of sum of resisting forces to sum of driving forces along the rupture line, is questionable, because curve is multicentered. However, several comparisons reveal reasonable agreement with results by other methods.

A quick, approximate method for getting pore pressures resulting from rapid draw-down is offered, together with an indication of method of incorporation in the stability analysis.

T. A. Farrent, Australia

Fracture (Including Fatigue)

(See also Revs. 6629, 6635, 6997, 7025)

6658. Grinter, L. E., Brittle fractures explained by negative residuals, *Proc. Amer. Soc. Civ. Engrs.* **87**, EM 2 (*J. Engng. Mech. Div.*), 25–33, Apr. 1961.

Analytical study of residual stress pattern near notch following precompression reveals lateral compressive residual stresses that are said to promote brittle fracture under tensile load. Tensile tests on precompressed notched plates and smooth cylinders conducted at Brown University are analyzed. Assumption of perfect elasticity and ideal plasticity neglects possibility of work-hardening damage as factor. Reviewer believes available test data do not support premise that biaxial residual compression can suppress ductility, for such stresses generally permit easier attainment of shear yield stress. D. K. Felbeck, USA

6659. Barenblatt, G. I., On some basic ideas of the theory of equilibrium cracks, forming during brittle fracture, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 21–38.

Paper summarizes author's contributions to theory of intracrystalline brittle fracture. Classical work of Inglis, Muskhelishvili, Griffith, Orowan and Irwin is reviewed, and attention is concentrated on effect of intermolecular forces in edge region between open crack and elastically strained crystal. No reference is made to work of Elliott [*Proc. Phys. Soc.* **59**, p. 208, 1947] on this topic.

Author postulates that configuration in edge region is independent of size of crack and of applied stress. Effect of intermolecular forces in this region can then be calculated and expressed in terms of single material constant, the *modulus of cohesion K*. Additional assumption that equilibrium length of crack under given stress must agree with that calculated by Griffith allows K to be expressed in terms of elastic constants and surface energy. Reviewer remarks that final assumption implies reversible breaking of intermolecular bonds, and may be less general than most of analysis. F. R. N. Nabarro, S. Africa

6660. De Leiris, H., Study of cyclic torsion of steel shafts repaired by casting (in French), *Bull. Assn. Tech. Marit. Aero.* no. 59, 251–271, 1959.

Steel shafts with repairs simulated by a central section of reduced diameter filled with cast metal are tested in cyclic torsion. Four types of surface preparation and two types of cast steel are examined. The type of metal is found to make no difference; mechanical roughening is found to be the best surface preparation prior to casting, although the resistance of a shaft so repaired is still about 20% poorer than that of an unrepaired shaft. There is, moreover, considerable scatter in the data.

H. C. Rogers, USA

6661. Pashkov, P. O., On rapid plastic disruption due to the action of the energy of elastic deformation (in Russian), Metallovedenie, Vol. 2, Leningrad, Sudpromgiz, 1958, 186–197; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14192.

The observation is made that the rapid disruption of the sample under tension (a plate), due to the elastic deformation of the structure or of the system machine-sample, is accompanied by plastic deformation in a localized region in the vicinity of the crack. The author substitutes for the Orowan differential condition [E. Orowan, *J. Appl. Phys.* **7**, 900–902, 1955] a condition in a finite form

$$\tau_* - \tau_0 = K_0 \sqrt{cW_* G (1 - l_*)} \qquad [*]$$

where τ_* is the critical tangential stress; τ_0 the resistance of the elastic deformation (to use the author's terminology); K_0 a constant; C the width of the region (along the sample) included in the plastic deformation; G the shear modulus; l_* the critical length of the transverse cut in the plate which results in the disruption of the sample; W_* the specific work of plastic deformation with the value of shear g_* at its limit. The condition (*) indicates that for the spontaneous disruption of the plate at a given length for the cut l_* it is essential that the elastic energy of the system machine-sample should be adequate to ensure critical shear being produced in the constricted "waist," that is, that this elastic energy should not be less than the work of plastic deformation at the critical value for the shear. The shear is assumed to be virtually homogeneous over the whole region of the plastic deformations. In the final stages of the breakdown concentration of stresses and the energy of disruption are disregarded.

Handled in this manner all the difficulties caused by the dynamic genesis and development of cracks are replaced by the condition of the simultaneous development of plastic deformations and of disruption over the whole of the transverse section and the computation of the work on this deformation. In the tests carried out on a machine of type PM-500 the load was imparted to the sample (in the form of a plate) through a spring absorbing the energy of the elastic deformation. A linear relation was obtained between the square of the load, leading to spontaneous disruption, and the length of the transverse cut in a plate of given dimensions made from a given material (technical aluminum, copper, brass, steel of low carbon content). The width of the region c was determined by the dimensions of the width of the plate after disruption.

V. S. Lenskii
Courtesy Referativnyi Zhurnal, USSR

6662. Pavlov, V. A., A study of the laws of plastic deformation and failure (in Russian), *Trudf In-ta Fiz. Metallov., Uralskii Fil. Akad. Nauk SSSR* no. 20, 245–263, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8256.

A survey of the activities of the laboratory of mechanical properties of the Institute of Metal Physics (Ural Branch of the Academy of Sciences of the U.S.S.R.) covers the last ten years, and deals with the problems of research on the mechanism of tensile

failure and plastic deformation of pure metals and single-phase solid solutions.

The proposition is defended that viscous (i.e. tensile) failure is the result of interaction between plastic deformation and the failure due to normal tensile stresses; and that the processes of failure have their origin in the earliest stages of plastic deformation, by the formation and development of micro-cracks. Data are given of observations on stress relaxation and the influence of temperature on the resistance to deformation of single-phase (solid) solutions. P. O. Pashkov

Courtesy Referativnyi Zhurnal, USSR

6663. Illg, W., Factors in evaluating fatigue life of structural parts, NASA TN D-725, 10 pp., Apr. 1961.

Note discusses effects of variable amplitude loading, crack propagation and varying mean load on crack propagation. Summarizes NACA TN 3816(1956); 4132(1957); 4394(1958); D-212 (1959). H. Fessler, England

6664. Smedley, G. P., and Batten, B. K., Fatigue strength of marine shafting, *Inter. Shipbldg. Prog.* **8,** 79, 105-118, Mar. 1961.

Actual marine shafting service is simulated by torsional fatigue testing of forged mild steel shafting with transverse holes of different diameters and with varying end radii; also of cast steel shafting with arc-welded "repairs." Comparisons with unnotched shafting are made. The influence of sea-water corrosive fatigue is also examined briefly. The results indicate that the cast steel shafts are as good as the forged steel shafts if good practices are used. The importance of end radii in improving the fatigue life of shafting with transverse holes is also demonstrated.

H. C. Rogers, USA

6665. De Leiris, H., Study of the means of increasing fatigue resistance of certain welded assemblies used in ship construction (in French), *Bull. Assn. Tech. Marit. Aero.* no. 60, 441-456, 1960.

Fatigue strength of welded structures can be improved by inducing a state of internal compressive stress at the locations where stress concentrations are to be expected. The inducement of these internal stresses may occur by local heating or hammering and in consequence the residual tensile stresses due to welding are relieved.

Author investigates a number of test specimens from steel with a thickness of 12 mm and a tensile strength of 60 kg/mm^2. The welding (V weld, 60°) was executed with 4-mm basic electrodes. The completed welds were cooled down and there upon hammered with an Arx pistol, model 3B. This is an air-driven pistol hammer in which the moving ram strikes a bundle of hardened steel needles. The needles are pressed on to the surface of the weld to be treated and the pistol is moved to and fro along the weld with a velocity of 50-100 mm/minute.

Without hammering the fatigue strength was reduced to 50-60% of the value of the base material; after hammering an increase to 70-80% occurred. Impact tests showed, without hammering, a transition temperature for brittle fracture of − 10 °C as compared with − 40 °C for the base material. After hammering the transition temperature proved to be about − 35 °C.

R. G. Boiten, Holland

6666. Frankel, H. E., Bennett, J. A., and Pennington, W. A., Fatigue properties of high strength steels, *Trans. Amer. Soc. Metals* **52,** 257-276, 1960.

A study, bearing directly on industrial practice, evaluated the influence of several metallurgical variables on the fatigue properties of high-strength steels. The rotating beam fatigue strengths of SAE 4340, Tioga and Deward steels as well as SAE 52100, with carbon contents ranging from 0.44 to 1.06%, were determined for a number of quenched and tempered conditions. Since fatigue strength was almost a linear function of hardness to a limiting value, the data could be adjusted to a single hardness value to determine effects of other variables.

Fatigue strength, authors conclude, was lowered by increasing amounts of retained austenite up to about 10%. Reviewer believes that this is significant data, since there has been little but speculation in this field to date. Deleterious effect of austenite was thought to be due to transformation of portions of this constituent during fatigue stressing.

Twenty-two references are given.

H. J. Heine, USA

6667. Shreiner, L. A., and Pavalova, N. N., Experimental data on the fatigue failure of rock formations (in Russian), *Trudi In-ta Nefti Akad. Nauk SSSR* **11,** 46-52, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 8081.

An investigation of the relationship between the speed of drilling in rock formations and the load on the drilling tool; a distinction is made between the regions of superficial, fatigue, and "normal" failure of the rock. The two first forms of failure take place at stress values below the yield strength. A comparison is made between the fatigue failure and the fatigue limit of metals and rocks. For both rocks and metals, a characteristic is the reduction in the fatigue limit with increasing inhomogeneity of the structure; the fatigue limit for these materials also depends on the conditions of the stress state, the medium, and the absolute dimensions of the samples. The number of load cycles N, required for the failure of rock formations at stress values approaching the yield limit, is some 5-6 orders of magnitude below the value for metals, the value of N being lower for brittle rocks of low plasticity than for rocks of higher plasticity.

For the purpose of investigating the mechanism of fatigue failure in rocks, as well as determining the fatigue limit and the value of N, tests were made on different rock formations under repeated, dynamic penetration (using a shore scleroscope). The instant of failure was determined from the decrease in the value of the recoil of the striker. The experimental equipment is described and the results recapitulated. From these data, an empirical formula has been derived determining the limiting value of the specific impact energy, not causing failure of the rock at $N = \infty$ (fatigue limit). The relationship of the fatigue limit to the specific energy of destruction at one flow (i.e., to the yield strength) is much lower than in the case of metals, being about 1 : 21 to 1 : 29 for the materials tested (dolomite, marble, and Solenhofes limestone). R. I. Kripyakevich

Courtesy Referativnyi Zhurnal, USSR

6668. Weibull, W., Size effects on fatigue crack initiation and propagation in aluminium sheet specimens subjected to stresses of nearly constant amplitude, *Flygtekn. Försöksanst. Medd.* **86,** 29 pp., June 1960.

Fatigue tests on axially-loaded 24S-T and 75S-T aluminum sheet specimens of various sizes were conducted with a constant nominal stress amplitude, established by a stepwise reduction of the load in proportion to the remaining cross-sectional area.

Earlier observations were confirmed, showing that, in this type of test, the crack propagates with a constant, stable rate of growth after a—generally short—transition period has been passed. This transition period was found to increase with the number of cycles necessary to initiate a visible crack.

A law, deduced by means of dimensional considerations and stating that the stable rate of growth should be proportional to the size of geometrically similar specimens, was well substantiated which implies that the relative rate of growth is, for a given stress amplitude and mean stress, a material constant.

For geometrically similar specimens, the period of crack initiation was observed to depend on the size of the notch and to increase with decreasing size, which is in accordance with the statistical theory of strength.

From author's summary

6669. Mains, R. M., A generalization of cumulative damage, *ASME Trans.* **82** D (*J. Basic Engng.*), 2, 435–440, June 1960.

In the application of various damage accumulation hypotheses to shock and vibration problems, a pattern of results was observed. A plot of allowable response (for the largest of a sequence of excitations) versus the number of excitations in the sequence produced straight lines on log-log paper for each value of damping. It seemed likely that a generalization could be found which would relate the allowable response to the largest excitations with a load-distribution factor, a material-and-structure factor, and the material constants from fatigue tests. One form of this generalization is presented, together with some numerical examples of its use, and a discussion of its possible significance.

From author's summary

6670. Hoar, T. P., Electrochemical techniques in stress-corrosion cracking (in English), *Ingenvetenskakad. Tidsk. Tekn. Forsk.* **32**, 3, 93–103, 1961.

6671. Forty, A. J., The metal physics of stress corrosion (in English), *Ingenvetenskakad. Tidsk. Tekn. Forsk.* **32**, 3, 104–121, 1961.

6672. Strom, B., The relation between microstructure and stress corrosion in aluminium alloys (in English), *Ingenvetenskakad. Tidsk. Tekn. Forsk.* **32**, 3, 122–131, 1961.

6673. Mattsson, E., Stress corrosion in brass against the background of potential/pH diagrams for the corroding system (in English), *Ingenvetenskakad. Tidsk. Tekn. Forsk.* **32**, 3, 132–138, 1961.

6674. Berg, S., and Henrikson, S., Influence of the chloride ion concentration on the stress corrosion of stainless steels at different temperatures (in English), *Ingenvetenskakad. Tidsk. Tekn. Forsk.* **32**, 3, 145–151, 1961.

6675. Bebchuk, A. S., and Rozenberg, L. D., Dependence of cavitation erosion on the solubility of a gas in a liquid, *Soviet Phys.–Acoustics* **6**, 4, 496–498 (Brief Comm.), Apr./June 1961. (Translation of *Akust Zh., SSSR* **6**, 4, 498–499, Oct./Dec. 1960 by Amer. Inst. Phys., New York, N. Y.)

Experimental Stress Analysis

(See also Revs. 6537, 6632, 6685, 6700)

6676. Young, L., Structural testing at high temperature, *Exper. Mech.* **1**, 7, 16–22, July 1961.

Paper describes the equipment and procedures used in testing a large multicell box beam under various combinations of applied loading and transient heating. Data are presented on the performance of radiant-heat lamps when enclosed by aluminum reflectors and powered by automobile-type batteries. In addition, solutions are given to the following special problems introduced by simulating fuel conditions: (1) sealing the specimen without disturbing the normal paths for heat flow; (2) protecting strain gages and thermocouples from the simulated fuel.

From author's summary by T. J. Dolan, USA

6677. Moseley, D. L., Testing methods for large aircraft, *Exper. Mech.* **1**, 5, 137–144, May 1961.

Some unique testing methods in connection with static-load application and associated data acquisition are described. The "free-flight" method of airplane static testing is covered as it applies to the current test program for the C-133 Cargomaster (300,000 lb gross weight). The loading and safety advantages of the "single-pressure concept" are discussed. Instrumentation provides for visual readout as well as IBM punch cards for records of deflection, cabin pressures, jack loads and up to a toal of 2800 strain gage installations. Use of the "Electromec," and safety methods for fuselages pressurized by air are discussed. Additional areas that are covered: hydrostatic-test methods and instrumentation; fail-safe development for pressurized cabins; and future of fatigue tests of a complete airplane.

From author's summary

6678. Mylonas, C., and Drucker, D. C., Twisting stresses in tape, *Exper. Mech.* **1**, 7, 23–32, July 1961.

An analysis is presented of the stresses induced in a thin tape by bending over pulleys, by axial tension and by twisting of the the tape when running between two out-of-plane pulleys. Analytical results are compared with some photoelastic tests on tape models made of epoxy resin. The weak retardation produced by the thin tape is multiplied by repeated light passage through the tape and is measured by a bent-beam compensator. The tests are of especial interest because the rate of rotation of the principal stresses is higher than had been encountered before. Surprisingly, the experimental results uncorrected for rotation are in good agreement with the calculated stresses.

From authors' summary by D. Frederick, USA

6679. Shimada, H., Influence of breadth in bars with reinforced circular holes under tension, *Exper. Mech.* **1**, 7, 33–39, July 1961.

Paper reports stress distributions in epoxy-resin bars with reinforced circular holes under tension. The holes were reinforced by bonding aluminum rings to the bars inside the holes. The stress distributions were determined photoelastically.

Various proportions of circular reinforcements and different widths of bars were investigated under pure tension. Stress distributions were determined in the epoxy-resin part of the bar, and the maximum shear stresses were given special attention. The relation between maximum shear stress and the width of the bar was determined, and the ranges for which the theoretical solution for an infinite bar approximates that for a finite bar were defined.

From author's summary by T. J. Dolan, USA

6680. Ades, C. S., and Lee, L. H. N., Strain-gage measurements in regions of high stress gradient, *Exper. Mech.* **1**, 6, 199–200, June 1961.

Technical note presents some of the data collected during measurement of maximum strain in regions of rapidly varying strain.

From authors' summary

6681. Scott, I. G., Errors in strain gauge bridge networks, Aero. Res. Lab. Melbourne, Austral. Rep. SM 276, 15 pp. + figs., Aug. 1960.

6682. Vigness, I., Shock motions and their measurement, *Exper. Mech.* **1**, 9, 13a–15a, Sept. 1961.

A review in expanded outline form is presented, wherein shock motions and means of their measurement are described. Because of their present popularity, more detailed considerations are given to piezoelectric accelerometers. References to recent literature are included which contain detailed considerations of these subjects.

From author's summary

Material Test Techniques

(See also Revs. 6531, 6663, 6857, 7028, 7030)

6683. Kegg, R. L., A new test method for determination of spinnability of metals, *ASME Trans.* **83** B (*J. Engng. Industry*), 2, 119–130, May 1961.

A new test for shear spinnability of 1/4-in. gauge material is described. The details of an ellipsoidal test mandrel are not given and the correlation of test results on different gauges of material is not discussed. The results from new spinnability test are correlated with tensile test results of specimens of the same gauge. The reduction of area appears to be in close relationship with maximum spinning reduction of this test for different materials tested. The elongation seems not to be correlated except perhaps for separate groups of materials. The comparison of test results and results of actual spinning of components is discussed in detail and the results of deviations from sine law are explained.

W. De O Byrn, England

6684. Ekhlakov, A. D., and Gladkovskii, V. A., A new method for the determination of the relation of Young's modulus for solid bodies to pressure (in Russian), *Fiz. Met. i Metall.* **7**, 1, 116–121, 1959; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14597.

A method is described for the experimental study of the relation of Young's modulus E to the pressure, based on the determination of the changes in rigidity of a cantilever-girder test sample when pressure is applied. The relation of E to the pressure was established by this means for aluminum, copper and steel mark 50; this relation up to pressures of 4000 Kg/cm^2 is linear. The method also enables measurements to be made of the compressibility of liquids.

I. A. Kiiko

Courtesy Referativnyi Zhurnal, USSR

6685. Filatov, F. I., The apparatus and method employed for the measurement of the resistance to deformation of metals and alloys (in Russian), Obrabotka Splavov Davleniem, Moskva, Oborongiz, 1958, 120–133; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14740.

A description is given of the apparatus and of the method used for the measurement of the mean specific pressures when deformation is caused by impact, and also of the results of experiments on the setting of samples of aluminum and magnesium alloys, constructional steels and a heat-resistant alloy on a vertical press. A flexible dynamometer was used for measuring the forces. A design was evolved for a graduated device enabling static graduation to be effected of the flexible dynamometer with wire strain gages glued to it; the gages are set in circuit with a bridge scheme using direct current; a wide-band electronic amplifier with reactive linkage between the amplifying gradations being utilized for the amplication of the voltage of the inbalance of the bridge of customary design. A plan and the construction was also worked out of an electronic oscillograph specially designed for the recording of amplification measurements. In a special recess in the oscillograph tube's assembly a photo inset of type FP-1 was fixed, enabling oscillograms to be photographed from the tube's screen. The specific pressure of the metals and alloys were determined on a vertical Amsler machine. The flexible dynamometer was attached to the anvil block of the machine by means of a special bracket. The test samples, 20 mm high and a diameter of 15 mm, were set in the center of the plate located above the flexible dynamometer. Three degrees of deformation were adopted: 10, 20 and 40% of relative deformation. The results of the measurements of the mean specific pressure were given in the form of graphs for aluminum alloys D16, V95, AK6, AK4 and AMts, magnesium alloys MA8 and MA5, steels of marks 30 KhGSA and 18 KhNMVA and for a heat-resistant alloy EI-437.

Yu. G. Maksimov

Courtesy Referativnyi Zhurnal, USSR

6686. Rakhmanov, A. S., and Livshits, L. S., The effect of the sharpness of the notches in impact-strength tests, *Indust. Lab.* **25**, 12, 1579–1581, Oct. 1960. (Translation of *Zavod. Lab., USSR* **25**, 12, 1502–1503, Dec. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

6687. Zasova, A. F., and Silkin, E. A., A method of studying the process of the destruction of samples under repeated-alternating torsional stress, *Indust. Lab.* **25**, 12, 1581–1582, Oct. 1960. (Translation of *Zavod. Lab., USSR* **25**, 12, 1504–1505, Dec. 1959 by Instrument Society of America, Pittsburgh 22, Pa.)

6688. Dutov, B. P., Durnov, A. S., and Krylov, N. A., The vibration method for the nondestructive testing of concrete (in Russian), Dokl. Mazhvuz. Konferentsii po Ispytaniem Sooruzh., Leningrad, 1958, 215–225; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14666.

Questions are investigated concerning the determination of the stability and deformation characteristics of concrete by the vibrational method of testing samples. In these tests the dynamic modulus and the coefficient of absorption of energy are found and also the relation between the found characteristics and the indicators of stability. The apparatus used is described; the vibration in the sample is effected by means of an exciter transmitting the vibtrations through an atmospheric medium. The authors hold the view that it is possible to use the following well-known equation to describe the processes of deformation of the concrete samples

$$\sigma + \tau_\varepsilon \dot{\sigma} = Mp\,(\varepsilon + \tau_\sigma \dot{\varepsilon})$$

where σ and $\dot{\sigma}$ are the stress and velocity of its change, ε and $\dot{\varepsilon}$ the relative deformation and velocity of its change, τ_ε, τ_σ, Mp coefficients depending on the rheological properties of the material.

P. I. Vasil'ev

Courtesy Referativnyi Zhurnal, USSR

Properties of Engineering Materials

(See Revs. 6534, 6652, 6665, 6666, 6668, 6683, 6879, 6881, 6885)

Structures: Simple

(See also Revs. 6538, 6542, 6564, 6656)

Book—6689. Mokk, L., Construction with prefabricated reinforced concrete parts [Bauen mit Stahlbetonfertigteilen], Budapest, Akademiai Kiado, 1960, 473 pp.

This book of practical character deals with the use of prefabricated elements of reinforced concrete in construction, especially of great halls and industrial buildings. The different aspects of prefabrication at construction site or in factory—description and design (on the elementary level) of the parts, forms, technology of materials, problems of transport, equipment and technics of lifting, fitting in place and the execution of joints—are the matters treated by the author. Throughout the work and in a special chapter devoted to remarkable precast constructions, he

gives a detailed description not only of the direct experience in Hungary, "country where the scarcity of steel and wood obliges the engineer to employ precasting on intensive scale," but also an interesting review of prefabrication in other countries, citing many articles on the matter. There are also some considerations about the economical aspects compared with other types of construction.

Due to the variety of subjects treated, the generality of treatment and the number of references, undoubtedly this book will be a useful aid for those interested in the problems of prefabrication.

J. L. Delpini, Argentina

6690. Meteliuk, I. S., Stresses and deformation in prefabricated structures due to slump of monolithic concrete (in Russian), *Gidrotekh. Stroit.* **31**, 1, 19-21, Jan. 1961.

6691. Mattock, A. H., Kriz, L. B., and Hognestad, E., Rectangular concrete stress distribution in ultimate strength design: Part 1, Review of basic assumptions; Part 2, Design equations, *J. Amer. Concr. Inst.* **32**, 8, 875-928, Feb. 1961.

The well-known contributors to the "ultimate strength design" propose a summarized and detailed theory for the practical design of reinforced-concrete members. The theory is based on detailed test programs, executed by authors and others, and on detailed statistical evaluation thereof. Authors prove the applicability of rectangular stress distribution even for eccentrically and unsymmetrical applied load, inducing "bending and compression of all types of structural concrete sections likely to be encountered in structural design practice, including odd-shaped sections and other unusual cases," and even prestressed concrete member. Practical numerical design tables, for problems dealt with, are given as an appendix.

Reviewer believes that this contribution may serve as basic information to the reinforced-concrete designer forming hereby a skeleton to a practical textbook on the subject. However reviewer objects to authors' sentence: ".... increase in load after yield of spirally reinforced column should be ignored...." Reviewer is of the opinion that authors' assumption is based on an early report of E. Hognestad [Hognestad, E., "A study of combined bending and axial load in reinforced concrete members," Bulletin no. 399, Engng. Exp. Sta., University of Illinois, Nov. 1951, p. 120-121] which assumed the rupture of outer shell as state of rupture of column, although the resistance of the internal core is not influenced. At this time, we may consider a possibility of forming an outer shell by a foreign material, and in such a case the safety of structure may rise, due to the spiral reinforcement.

E. Ben-Zvi, Israel

6692. Robertson, R. G., The three-span haunched continuous beam in prestressed concrete, *Proc. Instn. Civ. Engrs.* **18**, 67-80, Jan. 1961.

A method is described for calculating the economical span ratios, beam depth, and haunch sizes for continuous beams of three spans subject to a moving uniform live load.

The method is illustrated by a design chart and worked examples for haunched beams of I-section for comparison with previous designs for continuous beams of uniform I-section and with articulated continuous beams.

It is found that in all cases the use of the correct haunch proportions together with secondary moments gives the greatest economy of materials but that there is no perceptible difference between the economy of articulated beams and continuous beams.

From author's summary by C. J. Bernhardt, Norway

6693. Cakiroglu, A., Method of equivalent system in the calculation of statically indeterminate structure (in French), *Bul. Istanbul Tekn. Univ.* **13**, 1, 65-70, 1960.

A criterion of equivalence for beam end conditions is derived on the basis of bending deflections. Examples show how, in a complex beam problem, substitution of an element by an equivalent one might produce a problem with an already known solution.

P. F. De Neeve, Canada

6694. Luccio, M., Analytical determination of the more general case of the elasticity ellipse "in parallel": Part 1, General analytical study and general graphical solution of compressional elements; Part 2, Applications (in Italian), *G. Gen. Civ.* **98**, 1, 16-37, Jan. 1960; **98**, 2/3, 146-160, Feb./Mar. 1960.

Paper extends and generalizes methods developed by G. M. Pungo in "Teoria dell'ellisse di elasticità" (1952). Ellipse of elasticity is a geometrical concept, used in conjunction with method of elastic weights, and based on work of Culman, Ritter, and C. L. Ricci, for graphical analysis of deformations of beam and arch structures ("ordinary" ellipse of elasticity, described by Pungo as applicable to the Saint-Venant problem), and structural members, bent and twisted in space ("transverse" ellipse of elasticity, the Clebsch problem). Author extends treatment by considering composite structures, e.g. multi-storied rigid frameworks, as composed of elements to be treated in "pairs," hence the concept of the "parallel" ellipse of elasticity. Perusal of Pungo's treatise is essential to an understanding of subject matter of paper.

F. A. Gerard, USA

6695. Ferguson, P. M., Recent trends in ultimate strength design, *Proc. Amer. Soc. Civ. Engrs.* **87**, ST 1 (*J. Struct. Div.*), 57-71, Jan. 1961.

6696. Castillo Martinez, H., Invariants in arches (in Spanish), *Ingenieria, Mexico* **31**, 2, 64-67, Apr. 1961.

Author presents method of analyzing fixed-ended, nonuniform arch under arbitrary loads. Results are in terms of products of matrices, one of which involves only the properties of the structure (therefore termed "invariant") while the others involve the loads. Mention is made of an earlier paper by author but without specific reference.

M. P. White, USA

6697. Bonitzer, M. J., Rational calculation of highway pavements (in French), *Ann. Inst. Tech. Bât. Trav. Publics* **13**, 154, 1103-1120, Oct. 1960.

Author reviews what he considers to be the most important methods which have been developed for the rational analysis of roadways. He looks at the problem of the three-layered system consisting of the surface course, base course, and foundation course resting on the subgrade. He then proceeds to examine the assumptions that the material is (1) elastoplastic, (2) viscoelastoplastic, and discusses methods of analyses based on these assumptions. In discussing the properties of the materials in the multi-layered system the author discusses the significance of the triaxial soil test. Finally a field test procedure is described which is based on the measurement of displacements under vibratory loads and which might be used to check the theory. This paper is a "state of the art" type of exposition and its principal contribution is that it focuses attention on the real problems involved in the rational design of highway pavements and pavement foundations.

E. Vey, USA

6698. Hoskin, B. C., Limit analysis, limit design and linear programming, Aero. Res. Lab. Melbourne, Austral. Rep. SM 274, 28 pp. + figs., Feb. 1960.

Structures: Composite

(See Revs. 6571, 6573, 6584, 6588, 6610, 6645, 6676, 6679, 7022)

Machine Elements and Machine Design

(See also Revs. 6475, 6476, 6482, 6507, 6618, 6620, 6649, 6679)

6699. Erisman, R. J., Optimum design of helical compression springs, *ASME Trans.* **83** B (*J. Engng. Industry*), 2, 227–234, May 1961.

Author derives solutions for minimum-weight springs, and presents design charts for their rapid proportioning. Derivations are based on intermediate load with supplementary deflection, and allowable shearing stress. Energy absorption condition is not considered; however, the charts presented can still be used for preliminary estimate of ratio: outside spring diameter to wire diameter.

Reviewer feels when considering springs of minimum weight, one might observe that weight of helical springs can be reduced by making them of steel tubes or cables made of very thin steel wires. Shearing strength of thin steel wires is about twice that of wires of large diameters. J. A. Paczka, Argentina

6700. Kawamoto, M., Sakurai, T., and Fujitani, K., On the deformation and strength of coiled springs under repeated compression, Proc. Third Japan Congress on Testing Materials, Tokyo, Sept. 15–16, 1959; Japan Soc. Test. Mat., 1960, 33–35.

Paper discusses residual deflection and endurance limit of round-wire helical springs as affected by heat treatment and initial set. Experimental results are given for a single geometrical proportion for two materials and three pretreatments. Results confirm the familiar but nonetheless remarkable influence of heat treatment on spring characteristics.

W. J. Moreland, USA

6701. Sokolov, S. V., Calculation for preloaded plate-shaped springs and their experimental investigation (in Russian), Raschetyi na Prochnostv Mashinostr. (MVTU **89**), Moskva, 1958, 63–94; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 14566.

It is noted that preloading significantly increases the carrying capacity within the limits of elasticity, reduces the dimensions and the weight of the appliance. A method is worked out for the calculation for the springs with the use of an actual diagram of the tension-compression of the spring steel parts and taking into account the forces of friction produced on the faces of the plate when it is compressed. The assumption is made when solving the problem of plastic pressing that the meridianal section of the spring rotates without distortion as a single whole, under the action of axial compressive forces and the forces of friction. Formulas are derived, enabling determinations to be made of the force and the flexure at the moment of genesis of the plastic deformation, and also to construct the characteristic for the spring. An experimental investigation of the process of compression showed good agreement between the experimental and computed data. A numerical example is given and also the record of an investigation of the deformation in the elastic region when account was taken of the forces of friction. M. V. Khvingiya

Courtesy Referativnyi Zhurnal, USSR

6702. Macinante, J. A., Seismic mountings for large machine tools, *Engineer, Lond.* **210,** 5470, 880–883, Nov. 1960.

This paper describes a design procedure for vibration isolation systems using isolators arranged in an unsymmetrical layout. Author states this simple procedure has not been previously used. The procedure requires that the isolators have the same stiffness, are arranged in a common horizontal plane, are equally loaded, and that vertical vibration is not accompanied by motion in a horizontal plane. Any number of isolators may be used in a variety of locations to accomodate machinery having special geometric configurations. Design formulas are given and reference is made to other formulas and procedures already published. An appendix gives step-by-step instructions to carry out the design.

R. R. Bouche, USA

6703. The bearings book—a basic reference manual for design engineers, 1961 edition, Mach. Design, 256 pp.

6704. Moon, C. H., A simplified, universal procedure for designing cam profiles, *Mach. Design* **33,** 8, 179–187, Apr. 1961.

Fastening and Joining Methods

(See Rev. 6665)

Rheology

(See also Revs. 6775, 6800, 7034, 7037)

6705. Porter, R. S., and Johnson, J. F., Viscosity performance of lubricating base oils at shears developed in machine elements, *Wear* **4,** 1, 32–40, Jan./Feb. 1961.

... The effect of composition was studied with stocks of widely different viscosity and origin. Measurements were made in laminar flow from 100–210 °F or 38–99 °C from low shear to stresses above 10^8 dynes/cm^2. Tests were made with a carefully thermostatted, thin-film, concentric cylinder viscometer. The viscosity of most base oils was independent of shear to the highest stress conditions. Several oils, particularly those of high viscosity, showed small but experimentally significant viscosity losses at high shear.... From authors' summary by S. Corrsin, USA

6706. Johnson, M. W., Jr., Some variational theorems for non-Newtonian flow, *Physics of Fluids* **3,** 6, 871–878, Nov./Dec. 1960.

Variational theorem is formulated which has as its Euler equations and natural boundary conditions all of the differential equations and boundary conditions of the boundary-value problem under consideration. Other variational theorems follow from fundamental theorem. Conditions under which theorems obtained are minimum or maximum principles are discussed, and application to non-Newtonian flow in a tube is made.

From author's summary by G. Power, England

6707. Klausner, Y., Volume rheology of a two-phase system (in English), *Kolloid Z.* **174,** 2, 109–113, Feb. 1961.

A model consisting of a viscoelastic Burgers element in parallel with a plastic Saint-Venant element is applied to describe volume changes in soils under pressure. It is claimed that such a model explains anomalies in soil consolidation attributed by other investigators to shear deformations. J. A. Lewis, USA

6708. Reiner, M., Research on cross-stresses in the flow of liquids, Technion Res. Devel. Foundation, Haifa, Israel Tech. Rep. (Contract AF61(052)-223); 12 pp. + figs., 1960.

Hydraulics

(See also Revs. 6505, 6675, 6731, 6801, 6803, 6827, 6979, 6980, 6981, 7025)

6709. Magarvey, R. H., and Bishop, R. L., Wakes in liquid-liquid systems, *Physics of Fluids* **4**, 7, 800–805, July 1961.

Evidence is presented to support a stable drop wake configuration consisting of a double row of vortex rings. This wake pattern is observed to be characteristic of liquid drops moving through a disperse liquid phase with Reynolds numbers appropriate to a range of nonoscillating drops. The wake configuration displays a high degree of symmetry and periodicity in the shedding of vortices. The wakes are rendered visible by the scrubbing of an aniline dye from the drop as it passes through the continuous phase. The larger oscillating drops leave wakes in which many rings are present, but the symmetry of the smaller drops is lacking.

From authors' summary by H. R. Hazard, USA

6710. Govier, G. W., Sullivan, G. A., and Wood, R. K., The upward vertical flow of oil-water mixtures, *Canad. J. Chem. Engng.* **39**, 2, 67–75, Apr. 1961.

An experimental study of oil-water mixtures flowing vertically upwards. Configurations of both phases (slugs, drops, "froth," etc.) somewhat analogous to those of air-water mixtures are observed. Unless oil is in the continuous phase, its viscosity has little effect on the friction pressure drop.

G. Birkhoff, USA

6711. Pavlov, I. I., An investigation of the pressure pulses in the flow of a diphase medium (in Russian), *Naucbn. Trudi Mosk. Lesotekbn. In-ta* no. 9, 175–188, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 7844.

An investigation of the development of pressure pulses in the flow of a diphase medium (water-air) at a temperature of 20 °C in a vertical pipe of 9.5-meters length and 26-millimeters bore. The experimental method and equipment are described in detail. The variable pressure component was measured by means of a low-pressure, membrane gage. The experiments were made at a mixture velocity of 0.2–5.0 m/sec, with a specific flow volume of the gaseous component of 20–90%. The entry conditions were varied in the mixer, during blowing of air through the water, through special perforated cones with apertures of 0.5, 1.0 and 3.0-mm diameter, and without cones. Experimental relationships have been obtained between the amplitude and frequency of the pulsations and the test parameters; the amplitude of the pulsation increases several times as the (flow) velocity or the gas percentage increase, and, as a general rule, decreases with decreasing size of the perforations; within the limits of experimental accuracy, the frequency does not depend on the velocity, but rapidly decreases with increasing gaseous content; and slightly, with increasing diameter of the perforations.

A. S. Danilov

Courtesy Referativnyi Zhurnal, USSR

6712. Al'tshul', A. D., Kalitsun, V. I., Kislyuk, F. I., and Kamershtein, A. G., Hydraulic resistance of joints in pipe-conduits made by butt contact-welding using the KTSA-1 apparatus (in Russian), *Str-vo Truboprovodov* no. 1, 7–10, 1959; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 13584.

Curves and formulas are given for the determination of the hydraulic resistances in pipes with joints made by contact welding. Increase in the coefficient of resistance for tubes with joints is determined by the magnitude

$$K = 1 + \frac{\zeta_{cm} d}{\lambda l}$$

Here ζcm is the coefficient of the "standard" local resistance which is determined in relation to the diameter of the tube by means of the table given in the paper, d and l are the diameter and the length of the tube, λ is the coefficient of resistance for a tube with no joints.

P. G. Kiselev

Courtesy Referativnyi Zhurnal, USSR

6713. Rasizade, Ya. M., Determination of starting pressure for forcing a fluid in a long tube (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekb. Nauk, Mekb. i Masb.* no. 1, 139–141, Jan./Feb. 1961.

6714. Makarian, G. A., The steady, continuously varying motion of a liquid in nonprismatic channels (in Russian), *Izv. Akad. Nauk ArmSSR, Ser. Tekbn. Nauk* **11**, 2, 55–62, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 7653.

The equation of the steady, nonuniform motion of a liquid in a nonprismatic, open channel, is presented in the form

$$\frac{db}{dl} = \frac{1}{\Pi\, b/B}\left[-\frac{d\partial}{dl} + (1-\Pi)\frac{db}{dl} - \frac{\Pi}{B}\frac{\partial \omega}{\partial m}\frac{dm}{dl}\right]$$

$$\Pi = \frac{\alpha Q^2}{g}\frac{B}{\omega^3}$$

(in the paper, the minus sign has been omitted in front of the term $d\partial/dl$) in which ∂ = specific energy of the cross section; l = distance along the axis of the channel; b = bottom width of the channel; ω = area of the flow cross section; m = coefficient of the slope (gradient); B = width of the flow cross section at the top; h = depth; α = velocity correction; Q = flow volume; g = acceleration of gravity.

This equation is analyzed for the case that m = const and b = const, which has already been investigated by V. D. Zhurin ["Elementary applied hydraulics," Tashkent, 1925], and others.

Approximation methods are indicated for integrating this differential equation for the case that m = const, and: (1) the depth along the channel varies rectilinearly; (2) the flow moves with a constant depth.

V. B. Dul'nev

Courtesy Referativnyi Zhurnal, USSR

6715. Ippen, A. T., Drinker, P. A., Jobin, W. R., and Noutsopoulos, G. K., The distribution of boundary shear stresses in curved trapezoidal channels, Mass. Inst. Technol., Hydrodynamics Lab., Dept. Civ. Sanitary Engng. TR 43, 83 pp., Oct. 1960.

6716. Lebedev, I. V., Graphical-analytical method of velocity field design in a steady current at a sudden unilateral enlargement (in Russian), *Gidrotekb. Stroit.* **30**, 7, 39–43, July 1960.

6717. Tasai, F., Formula for calculating hydrodynamic force of a cylinder heaving on a free surface (n-parameter family), *Rep. Res. Inst. Appl. Mech., Kyushu Univ.* **8**, 31, 71–74 (Note), 1960.

Author presents equations for calculating hydrodynamics force, i.e., added mass and progressive wave height, for an n-parameter family of cylindrical forms heaving on a free surface as a function of oscillation frequency. Added mass coefficient C_a is derived for infinitely high frequency from which added mass can be calculated. Author's equations reduce to a Lewis-form section for n = 2.

C. E. Carver, Jr., USA

6718. Stern, M. E., The moving flame experiment, *Tellus* **11**, 2, 175–179, May 1959.

This analytical study was motivated by curiosity about an interesting experiment in which a flame is rotated around the outside bottom rim of a cylindrical vessel filled with water. The fluid acquired a net rotation opposite to that of the flame.

Paper offers an analytical explanation of this phenomenon, based on a two-dimensional model and considering that friction is the only force which can exert a net torque about the vertical.

D. M. Vestal, Jr., USA

6719. Kudryatsev, B. B., Dispersive action due to cavitation (in Russian), *Kolloid. Zb.* **21**, 1, 58–61, 1958; *Ref. Zb. Mekb.* no. 11, 1959, Rev. 13552.

The cavitation phenomenon is proposed as a means of making emulsions which are produced by passing jets of superheated steam into the liquid. Experiments were carried out on the emulsification of transformer oil (~3 ml) added to water (15 ml). The rapidity of this type of process is high, the mean duration of the experiments being 0.5 min. It was established that repeated fractionation increases the emulsion's capacity to disperse and also increases its homogeneity. A simple apparatus is proposed for the multistage dispersion of liquids. B. S. Kogarko

Courtesy Referativnyi Zhurnal, USSR

Incompressible Flow

(See also Revs. 6469, 6769, 6770, 6771, 6798, 6831, 6850, 6887, 6898, 6902, 6975, 6976, 6981, 7006, 7013, 7035)

6720. Morton, B. R., On a momentum-mass flux diagram for turbulent jets, plumes and wakes, *J. Fluid Mech.* **10,** 1, 101–112, Feb. 1961.

Relationship between momentum and mass flux in columnar flows is expressed by single ordinary differential equation; its solutions for various flows are discussed at length. Treatment deals with gross flow characteristics, all lateral features being suppressed by similarity assumption of fully developed turbulent flow. A. Powell, USA

6721. Platzman, G. W., The spectral form of the vorticity equation, *J. Meteorol.* **17,** 6, 635–644, Dec. 1960.

An analysis of the vorticity equation is given in relation to its transformation from real space to wave number space by means of spherical harmonics. The advantage of the treatment in spectral form is that no truncation errors are introduced after the basic equations are truncated in order to restrict the number of degrees of freedom, whereas the nonlinear aspects of the basic equations may lead to severe distortions of the solution in real space. The method when applied to low-order systems shows that no interaction takes place between the components of a two-component system. J. A. Businger, USA

6722. Wurtele, M. G., Lagrangian dynamics and the parcel method in atmospheric models, *J. Meteorol.* **17,** 6, 661–669, Dec. 1960.

It is shown that the results obtained with the parcel method in the study of atmospheric stability are consistent with the general Lagrangian equations of motion. A method is indicated to assess the validity of the parcel method in any given stability analysis. Two examples are given which illustrate the potentiality of further research with this method. J. A. Businger, USA

6723. Steiger, M. H., and Bloom, M. H., Axially symmetric laminar free mixing with large swirl, AFOSR 400 (Polyt. Inst. Brooklyn, Dept. Aerospace Engng. Appl. Mech., PIBAL Rep. 636), 22 pp., Jan. 1961.

6724. Hodge, R. I., Frictional pressure drop in noncircular ducts, *ASME Trans.* **83**C (*J. Heat Transfer*), 3, 384–385 (Tech. Briefs), Aug. 1961.

6725. Weske, J. R., and Rankin, T. M., Production of secondary vortices in the field of a primary vortex, AFOSR 623 (Univ. Maryland, Inst. Fluid Dynam. Appl. Math. TN BN-244), 18 pp. + figs., Apr. 1961.

6726. Donaldson, C. duP., and Sullivan, R. D., Examination of the solutions of the Navier-Stokes equations for a class of three-dimensional vortices: Part 1, Velocity distributions for steady motion, AFOSR TN 60-1227 (Aero. Res. Associates, Princeton, Inc.), 82 pp., Oct. 1960.

6727. Brocard, J., Control of circulation around a circular cylinder, AFOSR TR 60-181 (Compagnie Rech. Etudes Aero. Final Tech. Rep.), 17 pp. + charts, Oct. 1960.

6728. Volkov, E. V., On rotation of isothermal flow of gas in cyclone chamber (in Russian), *Teploenergetika* no. 8, 32–37, Aug. 1960.

6729. Chandrasekhar, S., The hydrodynamic stability of inviscid flow between coaxial cylinders, *Proc. Nat. Acad. Sci., Wash.* **46,** 1, 137–141, Jan. 1960.

Author treats case of stability of inviscid flow between coaxial cylinders for case of axisymmetric perturbations. An analog to Rayleigh's criterion for stability of plane parallel flow is derived. Author notes disagreement with earlier work of Goldstein; author's results show that for inviscid flow the presence of an axial flow does not affect Rayleigh's criterion. G. V. Bull, Canada

6730. Chandrasekhar, S., The hydrodynamic stability of viscid flow between coaxial cylinders, *Proc. Nat. Acad. Sci., Wash.* **46,** 1, 141–143, Jan. 1960.

Author calculates the underlying characteristic value problem to check further disagreement with Goldstein's results; see preceding review for the case of a small gap between the cylinders and infinitesimal perturbations of the flow. He derives the critical Taylor's number as a monotonic increasing function of Reynolds number, contrary to the Goldstein result. G. V. Bull, Canada

6731. Dumitrescu, D., and Ionescu, V., Two-dimensional flow in vertical plan on infinite weir (in German), *Rev. Mécan. Appl.* **5,** 3, 329–342, 1960.

Paper concerns theoretical research on two-dimensional flow of an inviscid liquid on a weir of very general shape, under the influence of gravity.

The research is reduced to the solution of a plane harmonic problem in a semicircle; but the boundary conditions along the semicircumference, derived from Bernoulli's theorem, are nonlinear. The proposed solution is through successive approximations; the convergence conditions are studied, which fail only at infinity downstream. D. Citrini, Italy

6732. Bourrieres, F.-J., Intrinsic equations of three-dimensional viscous flow (in French), Publ. Scient. Tech. Min. Air, France no. 368, 65 pp., 1960.

The present work establishes rigorously the explicit intrinsic equations for the stationary three-dimensional motion of an incompressible viscous fluid.

The generalization to three dimensions is made possible by a theorem that in effect relates longitudinal geometrical phenomena with transverse phenomena. The theorem is: on the surfaces orthogonal to the streamlines, the curves tangent to the principal normals (and binormals) of the streamlines are lines of curvature. From author's summary by H. C. Levey, Australia

6733. Rodet, E., Study of fluid flow in a prismatic tunnel of trapezoidal cross section (in French), Publ. Scient. Tech. Min. Air, France no. 369, 96 pp. + charts, 1960.

This paper is an experimental study of the turbulent flow of air in a duct of trapezoidal cross section and it is important for the understanding of the flow in heat exchangers with longitudinal fins. The following numerical results are presented for four

values of the Reynolds number (from 6×10^4 to 48×10^4): (a) the mean velocity distribution in the turbulent core and in the laminar sublayer; (b) values of five components of the Reynolds stress ($\overline{u^2}$, $\overline{v^2}$, $\overline{w^2}$, $\overline{uv}$, $\overline{uw}$). In the corners the velocity was relatively high and the turbulence showed a great decrease. The calculated wall shearing stress was zero at the corners and presented a relative minimum at the middle of each side of the duct. These results are compared with the calculated velocity distribution (by a relaxation method) and wall shearing stress in the laminar flow.

G. Brunello, Brazil

6734. Gerashchenko, O. A., and Nazarchuk, M. M., The magnitude of the region of drag in front of the inlet edge of a plane plate (in Russian), *Dop. Akad. Nauk URSR* no. 4, 390–392, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13657.

The steady flow of a viscous incompressible liquid in front of a plane plate is investigated. The authors find the following evaluation for the distance $|x_0|$ from the leading edge upstream in the flow at which the decrease of the full pressure constitutes an assigned portion of the initial velocity pressure:

$$|x_0| < \frac{2}{\alpha} \frac{\nu}{U_\infty}$$

This was accomplished by integration of the equation along the line of current coinciding with the axis of symmetry of the flow and by utilizing the symmetry of the flow relative to this axis and the conditions to infinity. In the evaluation U_∞ is the velocity of the incoming flow, ν is the kinematic viscosity, α the lost portion of the initial velocity pressure. For instance, for water with $U_\infty = 1$m/sec at 20° at a distance of 0.2 mm in front of the edge of the plate $\alpha < 0.01$, in other words, the region of drag is of extremely small extent.

G. G. Chernyi

Courtesy Referativnyi Zhurnal, USSR

6735. Pemberton, P. F., The effect of two-phase flow on the control characteristics of a liquid oxygen transfer system, *Instn. Engrs. Austral. EM* 3 (*Elect. Mech. Engng. Trans.*), 1, 25–28, May 1961.

The designers elected to avoid two-phase flow during topping-up of a missile. They used a charging system (high flow rate) and then a topping system which allowed precise flow control. Details of the analysis of control characteristics are given in order to show how to avoid the two-phase state.

W. L. Sibbitt, USA

6736. Zarea, S., The helicoidal Gromeca-Beltrami motion of an ideal fluid in a cylindrical circular pipe (in French), *Bul. Inst. Politehnic, Bucuresti* **20**, 2, 65–69, Apr./June 1959.

Compressible Flow (Continuum and Noncontinuum Flow)

(See also Revs. 6462, 6720, 6736, 6788, 6791, 6792, 6794, 6807, 6810, 6811, 6812, 6813, 6816, 6817, 6818, 6835, 6837, 6862, 6872, 6874, 6875, 6876, 6896, 6900, 6902, 6920, 6924, 6925, 6934, 6953, 6962, 6973)

Book—6737. Krzywoblocki, M. Z., Bergman's linear integral operator method in the theory of compressible fluid flow, Wien, Springer-Verlag, 1960, ix + 188 pp. $12.40.

Book describes Bergman's linear integral operator method in such a way that an aerodynamicist can use it in practical applications. Emphasis is put upon the simplified representation of the final results and formulas, rather than upon the derivations of these formulas. Bergman's method is scattered throughout many papers in mathematical journals, and, as a matter of fact, in its present state, is accessible only to those who are fully acquainted with mathematical literature. Thus the present work may well serve the purpose of making the theory of compressible fluid flow more comprehensible from a physical point of view by the use of the appropriate mathematical techniques. An acquaintance with Bergman's method requires slightly more mathematical knowledge then is usually assumed.

In the preliminary remarks, author discusses various types of singularities in a very elementary way. The first two parts of the work deal with the subsonic case. Part III contains the supersonic flow, Part IV the transonic flow and Part V the axisymmetric flow. These sections are based on Bergman's original papers and form a condensation of several of his papers on the subject. Part VI describes singularities which play an important role in all hodograph transformations. Part VII reviews other methods available in the theory of compressible fluid flow. Subsequent parts contain tables, general remarks and examples. Part XIII contains generalization to diabatic flow, Part XIV three-dimensional flow and Part XV (by Davis and Rabinowitz) contains some computations of subsonic fluid flow by Bergman's method of integral operators.

J. N. Aguirre, Argentina

6738. Schwarzenberger, R., On exact solutions of the equations of gas dynamics (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 151, 31 pp. Feb. 1961.

Simple solutions of the hodograph equations that represent generalizations of incompressible source-flow, vortex flow and multipoles are obtained. Limit lines are always present in the supersonic regions.

Solutions of this type are well known and, indeed, the author acknowledges that he did this work in 1944.

H. C. Levey, Australia

6739. Bolotin, V. V., On the application of piston theory for determination of aerodynamic forces acting on an oscillating shell (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 159–162, Jan./Feb. 1961.

To determine the limits of application of piston theory a comparison is made with the known exact solution of oscillating infinitely long circular cylindrical shell. It is shown that the piston theory approximation is obtained as the asymptotic case of the exact solution, when the additional condition of quasi-stationary flow is fulfilled.

A supplementary requirement that the coefficient of lateral deformation must be small as compared with the longitudinal one is obtained.

For the case of a plane shell an additional condition is shown and it is stated that the case of finite length shells and plates remain open.

W. Fiszdon, Poland

6740. Eletskii, A. V., Gas flow with partial relaxation past a wedge (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* 1, 2, 54–63, 1960.

A multiatomic gas flow is considered. The degrees of freedom of the gas molecule have been divided into "active", having short relaxation time, and "inert", ones having long relaxation time of the order of time necessary to traverse a distance equal to the chord length. It is assumed that the ratio δ of specific heat to the gas constant of the inert gas is much less than one and hence its relaxation effects are very small.

A power-series expansion in δ is assumed as a solution of the differential equations and boundary conditions. An approximate solution, linear in δ, is found and a linear approximation for the

values of drag, wall temperature and shock-wave equation is deduced.

It is shown that relaxation effects produce a reduction of the drag and wall temperature and an inflection of the shock wave toward the wedge. W. Fiszdon, Poland

6741. Stoltz, W. G., The critical and two-phase flow of steam, *ASME Trans.* **83** A (*J. Engng. Power*), 2, 145–154, Apr. 1961.

Results of a digital computer and analytical study of the critical flow of a compressible fluid are presented. The expanding flow of a fluid to a single-phase and to a two-phase region was studied.

From author's summary by W. L. Sibbitt, USA

6742. Helliwell, J. B., Unsymmetrical flow patterns past a finite wedge profile in a high subsonic stream, *Proc. Camb. Phil. Soc.* **57**, 2, 401–414, Apr. 1961.

The flow pattern past a thin wedge-like profile set at a small angle of attack in a gas flowing with high subsonic or sonic velocity is discussed within the order of the transonic approximation. In the model considered the flow has a stagnation point at the nose of the wedge and breaks away, with velocity equal to that of sound, from the shoulders. The velocity is subsonic throughout the whole field of flow. The solution of the boundary-value problem for the wedge in a channel is formulated as a pair of dual integral equations. The complete solution is given for the wedge in a free stream and the dimensions of the profile, together with the lift coefficient, are computed as functions of the transonic similarity parameter.

From author's summary by S. D. Nigam, India

6743. Watson, E. C., and Peterson, W. P., An experimental investigation of the flow in an axisymmetric internal-compression inlet for M = 2.75, NASA TN D-784, 56 pp., Apr. 1961.

Pressure measurements were made in the flow field and boundary-layer regions in the supersonic portion of an axisymmetric internal-compression inlet at Reynolds number between 3.1 and 4.6 million. Local properties of the flow, shock-wave patterns and the boundary-layer growth through the inlet were determined.

J. V. Becker, USA

6744. Hsu, C.-T., and Anderson, D. A., Effect of deceleration on pressure distribution along a slender cone in supersonic, transonic, and subsonic flight, *J. Aerospace Sci.* **28**, 2, 173–174 (Readers' Forum), Feb. 1961.

Unsteady potential for the flow at and near surface of very slender cones is used in generalized Bernoulli equation to obtain inertial pressure coefficient (same as J. D. Cole's approach in 1953). Its dependence on Mach number and amount of deceleration is discussed and plotted for the special case of a cone with 5° semiangle. H. K. Beckmann, USA

6745. Ohman, L., The application of a Lighthill formula for numerical calculation of pressure distributions on bodies of revolution at supersonic speed and zero angle of attack, SAAB Aircr. Co., Linköping TN 45, 23 pp., Sept. 1960.

From the Lighthill formula ["General theory of high speed aerodynamics," W. R. Sears, editor, Section E7: Higher approximations], author deduces several approximate formulas for the axial perturbation velocity on cones, double-cones and cone-cylinders, displaying comparisons between these and exact solutions (Prandtl-Meyer; Kopal tables), showing that some of the equations derived agree better than do the correct linearized and the slender body solutions. For a digital computer, the Lighthill formula is rewritten in an approximate form (by definition of Stieltjes integral) as a summation involving the rate of change of cross-sectional area. C_p is deduced from the velocity using the isentropic-flow equation. Taking areas at 60 axial stations, calculations are performed for several pointed bodies of revolution including the Karman ogive and hypersonic optimum. In cases where experimental results are also given, the calculations agree well with these.

Paper concludes that Lighthill's formula agrees with exact theory and/or experiment over wider ranges of Mach number and thickness than generally expected for a linearized theory.

Reviewer's opinion is that this is a valuable paper giving interesting and useful results. A. E. Brock, England

6746. Marini, M., Linearized supersonic flow in a jet or in a quasi-cylindrical tube (in Italian), *Atti Accad. Naz. Lincei, R. C. Cl. Sci. Fis. Mat. Nat.* **28**, 6, 802–806, June 1960.

Paper deals with a supersonic gaseous stream with axisymmetry flowing inside a quasi-cylindrical tube or from a uniform velocity jet issuing from a nozzle into a stationary gas.

S. Eskinazi, USA

6747. Kogan, A., A practical method for calculation of pressure distribution on airfoils in supersonic rotational flow, *Bull. Res. Council Israel* **8**C, 1, 17–24, Feb. 1960.

In an earlier paper [*J. Aero. Sci.* **27**, 504–508, 516, 1960; AMR **14**(1961), Rev. 3105] the same author constructed a theory for "thick airfoils" in supersonic flow; namely a second approximation for airfoils producing shock waves and appreciable vorticity. It consisted essentially in using the streamwise Cartesian coordinate and the Crocco stream function as independent variables. Here the construction of such tables is discussed and their practical application to the computation of pressure distributions on airfoils is outlined. W. R. Sears, USA

6748. Zandbergen, P. J., and Van Der Walle, F., The approximate influence of base-drag on the optimum shape of axisymmetric configuration in linearized supersonic flow (in English), Nat. LuchtLab. Amsterdam Rap. G. 14, 22 pp. + figures, 1960.

This report presents a method for the determination of the optimum shape of axisymmetric configurations taking the approximate influence of the shape on the base-drag into account. It is shown that the optimum shape derived in this way differs essentially from the shape derived when the base drag influence is not considered.

An optimization analysis, in which this base-drag influence is considered, leads to a less slender fuselage, in which the cross section of maximum area lies at some distance before the base, thus resulting in a shape with boattailing.

From authors' summary

6749. Album, H. H., Spiked blunt bodies in supersonic flow, AFOSR 307 (Mech. Division, Office Aero. Res.), 53 pp. + figures and tables, June 1961.

6750. Beane, Beverly J., Supersonic drag characteristics of partial-ring wings, Mass. Inst. Technol., Naval Supersonic Lab. TR 444, 169 pp., Sept. 1960.

6751. Brong, E. A., and Leigh, D. C., Surface streamlines in three-dimensional hypersonic flows, *J. Aerospace Sci.* **28**, 7, 585–587 (Readers' Forum), July 1961.

In this note several estimated inviscid flow surface streamlines on swept-back wedge cylinders are compared. The streamlines were calculated by the following procedures; the Newton-Busemann geodesic approximations, the path of steepest descent from the stagnation point to infinity when the streamline is constrained in a plane containing the surface normal and direction of the free-stream flow, the pressure method, and by superposition of the two-dimensional flow normal to the leading edge and the spanwise flow. Since the tips of the wedge cylinders are infinitely far removed, this superposition provides exact solution for the streamline.

The results indicate that the first two procedures do not provide as good approximation to the "exact" results as the pressure method. No reason for the failure of the first two procedures or the success of the third is given. The third procedure involved explicitly the assumption that near the body the normal derivative of the pressure is independent of the distance from the body and is based upon the experimental pressure distribution on the surface. Reviewer feels that the application of the third procedure to the infinitely long, sweptback configuration contains all the elements of the problem and the good agreement follows. However, application to the general three-dimensional problem would seem to require an iterative procedure that is based upon the pressure distribution along an assumed streamline. Until a convergent iteration procedure has been worked out the applications of this technique are expected to be limited.

E. E. Covert, USA

6752. Schouing, R. A., Outer inviscid hypersonic flow with attached shock waves, *ARS J.* **31,** 4, 486–505, Apr. 1961.

Methods to compute hypersonic flows over general bodies are reviewed and extensions are described which include: (a) two-dimensional shock expansion to include the effect of the reflection of Mach waves from the bow shock and vorticity layer; (b) conical flow over flat plates using equations specialized to apply to specific domains of interest; (c) Newtonian method applied to conical flows. (Note: A similar analysis has been carried out by Cole and Messiter at GALCIT.)

H. Yoshihara, USA

6753. Waldman, G. D., and Probstein, R. F., An analytic extension of the shock-expansion method, *J. Aerospace Sci.* **28,** 2, 119–132, Feb. 1961.

Authors develop a method for approximating the inviscid, rotational, high-speed flow of a perfect gas around a two-dimensional convex airfoil with sharp leading and trailing edges. The basic flow pattern is assumed given by the isentropic shock-expansion method with straight characteristics. Employing an analytic form of the solution, a perturbation method is developed for simple waves interacting with oblique shocks. The method is illustrated on a family of parabolic airfoils and compared with the method of characteristics. Authors conclude that the method is accurate and that the numerical calculations are simpler than in the method of characteristics.

E. Haynes, USA

6754. Bouniol, F., Rapid method for the calculation of parameters of hypersonic flow in real gas in thermodynamic equilibrium (in French), *Rech. Aéro.* no. 78, 21–22, Sept./Oct. 1960.

It is shown how the gas tables for a perfect gas may be used for title purpose in conjunction with relatively slowly-varying correction factors.

H. C. Levey, Australia

6755. Jarre, G., On the effects due to dissociation and ionisation at hypersonic velocities (in Italian), *Aerotecnica* **40,** 2, 99–111, Apr. 1960.

A study of dissociation and ionization of constituents of air at high temperatures produced by hypersonic velocities, either downstream of a strong normal shock wave or on plane adiabatic walls parallel to the flow. The thermochemical equilibrium state is analyzed with the help of a thermodynamic diagram of atmospheric air. The dynamical problem of relaxation is also resolved, but only for the speeds at which dissociation of oxygen takes place. Simplified methods and numerical examples are given.

S. Eskinazi, USA

6756. Penland, J. A., Aerodynamic force characteristics of a series of lifting cone and cone-cylinder configurations at a Mach number of 6.83 and angles of attack up to 130°, NASA TN D-840, 45 pp., June 1961.

Force tests of a series of right circular cones having semivertex angles ranging from 5° to 45° and a series of right circular cone-cylinder configurations having semivertex angles ranging from 5° to 20° and an afterbody fineness ratio of 6 have been made in the Langley 11-inch hypersonic tunnel at a Reynolds number of 0.24×10^6 per inch. An analysis of the results made use of the Newtonian and modified Newtonian theories and the exact theory.

From author's summary

6757. Mishra, R. S., A problem in shock waves (in English), *Nuovo Cim.* **20,** 4, 605–609, May 1961.

"Landau and Lifshitz (1959) ['Fluid Mechanics' (translated in English), London] have mentioned the following result: *If two (or more) successive shock waves take a gas from state 1 to state 2 and from there to state 3, the transition from state 1 to state 3 cannot, in general, be affected by the passage of any one shock wave.* The object of this note is to obtain conditions for the transition from state 1 to state 3 to be affected by the passage of any one shock."

In fulfillment the note offers:

Theorem: *If two successive* (oblique, steady) *shock waves* $S_{\alpha 1}(\alpha = 1,2)$ *of positive strengths take a gas from state 1 to state 2 and from there to state 3 at a point* P *the necessary and sufficient condition that the transition from state* 1 *to state* 3 *be affected by the passage of a single shock* S, *is that the three shock surfaces* $S_{\alpha 1}$ *and* S *are tangential to one another at* P.

Since the Rankine-Hugoniot relations are here intended to define shocks and these relations involve only normal (or tangential) components of flow variables at a point of a shock, the sufficiency is trivial but necessity is not.

For the reviewer, introducing the condition "at a point P" begs the question, nor is the meaning of the "if" clause in the theorem evident if shocks $S_{\alpha 1}(\alpha = 1,2)$ are not tangent at P. It would presumably be meaningful to examine the same question at points on the shock in an arbitrarily small neighborhood of "P" but the proof as given conceals this if it is the intent of the author to so interpret "at a point P."

It would seem that the condition that tangential components of velocity be preserved across the shock has been omitted in stating the Rankine-Hugoniot relations.

From author's summary by H. M. Lieberstein, USA

6758. Power, G., and Smith, P., Reciprocal properties of plane gas flows, *J. Math. Mech.* **10,** 3, 349–360, May 1961.

Author obtains certain reciprocal properties for a two-dimensional steady rotational gas flow of an inviscid and thermally nonconducting fluid which obeys a general equation of state. He concludes that any solution to the equations governing the motions for a given equation of state generates a class of solutions; to each solution there corresponds a certain equation of state. The particular instance of a gas obeying a product equation of state is discussed with special reference to the substitution principle and the canonical equations. Author shows that the reciprocal equation of state will also be of the product type provided the stagnation pressure is uniform. Under a further restriction, he shows that a shock remains a shock throughout all the class of flows. Class of equations of state which are invarient under the group of transformations is also examined.

P. N. Hu, USA

6759. Enig, J. W., Stability criteria for numerical solutions in unsteady two-dimensional cylindrical Lagrangian flow, *J. Math. Phys.* **40,** 1, 23–32, Apr. 1961.

Conditions for stability according to the von Neumann criterion are derived for the von Neumann-Richtmeyer pseudo-viscosity model for unsteady axially symmetric flow and for finite difference approximation methods used with this model, the methods of analy-

sis being an extension of those used by von Neumann and Richtmeyer on the pseudo-viscosity model for one-dimensional unsteady flow. Extensive satisfactory machine computational testing of the stability conditions is reported. The finite difference analysis treats a *shock region*, in which certain specializing assumptions are made, and a *normal region* in which others are made. A maximum time step Δt is derived which gives stability for each region and a minimum of the two Δt's used as a practical limit for the time step. It may be noted that since time-dependent problems only are considered, no elliptic regions can be encountered.

The fundamental assumption on which the von Neumann stability criterion is based, that stability characteristics for a quasi-linear differential system (or its finite difference analog) are the same as for that system with coefficients of the highest order terms replaced by constants, is still with us and results of this criterion should be, as they are here, accompanied by machine testing. Also, the heuristic nature of the pseudo-viscosity model with which one hopes to approximate what appears to be in the nature of a weak solution of a nonlinear hyperbolic system of equations is still in evidence. These methods seem effective, are supported by competent, serious scientific effort as here in evidence, and until it is possible to approximate "weak solutions" for nonlinear equations with computable "realistic" error bounds the results of this paper probably should be an important tool of technology. At the present time, the reviewer still prefers a model in which a shock is treated as a "saltus" line of discontinuity between two regions where separate (if the gas law is changed across the shock) differential systems are required to be satisfied. H. M. Lieberstein, USA

6760. Hsu, C.-T., On the gradient functions for nonequilibrium dissociative flow behind a shock, *J. Aerospace Sci.* **28,** 4, 337-339 (Readers' Forum), Apr. 1961.

Note considers dissociating diatomic gas flow behind shocks of prescribed curvature and compares results with those of Sedney [*J. Aerospace Sci.* **28,** 189-196, 1961] dealing with vibrational relaxation. Internal molecular states are taken to be in equilibrium with translational temperature in present note. Reviewer remarks on unnecessarily restrictive use of a linearized chemical reaction rate expression in definition of function f_1 below Eq. 26. J. F. Clarke, England

6761. Allen, W. A., and Rogers, J. W., Hugoniot curve determined by shock wave detachment from an infinite wedge, *Physics of Fluids* **4,** 4, 493-497, Apr. 1961.

Hugoniot curve of fluid flowing past a wedge is determined if we know experimental relation between incident fluid velocity and biggest wedge angle at which attached shock can exist at this fluid velocity. Authors describe technique which from this experimental data and approximate Hugoniot curve produces a better approximation. Example is described in which error was reduced from 10 per cent to 1 per cent by one application, using, however, a 709 computer. J. Comer, England

6762. Pavlov, K. B., On the theory of motions of the Prandtl-Meyer type, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 1, 227-229, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

The perturbation method is applied in the case of linearized Prandtl-Meyer flows if the initial parameters are almost constant. Introducing a cylindrical system of coordinates a self-similar problem, where all quantities are functions of angle φ only, is obtained. The solution of the linearized problem is reduced to the integration of a system of three linear first-order equations.

The results are useful to determine the flow on bodies behind curved shock waves. W. Fiszdon, Poland

6763. Witteman, W. J., Instrument to measure density profiles behind shock waves, AFOSR 364 (Univ. Maryland, Inst. Fluid Dynam. Appl. Math. TN BN-232), 18 pp., Feb. 1961.

6764. Narasimha, R., Orifice flow at high Knudsen numbers, *J. Fluid Mech.* **10,** 3, 371-384, May 1961.

Both free-molecule flow and small departures from that conceptual limit are considered. Perturbation of the limiting distribution function yields a first-order correction inversely proportional to Knudsen number and a consequent expression for the mass flow rate in agreement with Liepmann [*J. Fluid Mech.* **10,** 65-79, 1960; AMR **14**(1961), Rev. 4283]. Experimental comparison (ibid) indicates that the first-order correction ("nearly" free-molecule flow) is valid for Knudsen numbers as small as unity (based on orifice radius). J. R. Baron, USA

6765. Kobayashi, R., Physical theory of near free-molecule flow, *Trans. Japan Soc. Aero. Space Sci.* **3,** 4, 1-12, 1960.

A theoretical method is proposed for studying flows in the transition region between the free-molecule and continuum regimes. The free path of the molecules is described by a probability law which involves a time constant which must be determined from experiment. A general method for carrying out the computations is outlined, and the application of the theory to rarefied Couette flow is described. G. A. Bird, Australia

6766. Center, R. E., The interaction of a rarefaction wave with a wire grid, Aero. Res. Lab. Melbourne, Austral. Rep. A 118, 47 pp. + figs., Dec. 1959.

6767. Yoshikawa, K. K., and Katzen, E. D., Charts for air-flow properties in equilibrium and frozen flows in hypervelocity nozzles, NASA TN D-693, 70 pp., Apr. 1961.

Charts for title problem have been prepared for temperature between about 100-20,000° R and pressure up to about 10,000 psia calculating results of temperature, pressure, density, velocity, etc., and are given as function of area ratios along the nozzle.

There is a common but serious error. Everywhere, the ratio of specific heats has been used indiscriminately as the isentropic exponent, whereas the two differ by a factor which is given by $(d \log p/d \log v)$ along an isothermal. This factor is unity only for ideal gas. For equilibrium flow at high temperature and low pressure or for frozen flow at high pressure and low temperature, the air cannot be lightly considered as an ideal gas. The charts for equilibrium flow are calculated directly from Mollier charts and are correct except the values relating to Mach numbers. Other charts must be used with precaution.

L. S. Dzung, Switzerland

6768. Portnoy, H., On certain functions arising in the linearized theory of the supersonic jet, *Quart. J. Mech. Appl. Math.* **14,** 1, 29-35, Feb. 1961.

The article attempts to elaborate the properties of the operational function $F_n(z) \equiv I'_n(p)/pI_n(p)$ and succeeds in developing analytical forms convenient for tabulation. It may be of use to those working on the theory of supersonic jets. The list of references does not include corresponding Soviet papers.

G. A. Tokaty, England

6769. Hirschkron, R., and Healzer, J. M., Turbine-nozzle wake prediction, *J. Aerospace Sci.* **28,** 4, 334-335 (Readers' Forum), Apr. 1961.

Boundary Layer

(See also Revs. 6709, 6729, 6730, 6751, 6797, 6821, 6869, 6873, 6875, 6876, 6883, 6915)

6770. Sakiadis, B. C., Boundary-layer behavior on continuous solid surfaces: Part 1, Boundary-layer equations for two-dimensional and axisymmetric flow, *AIChE J.* **7,** 1, 26–28, Mar. 1961.

Author considers the boundary layer on a moving solid surface when the fluid at infinity is at rest. The corresponding momentum integral equations are derived from the boundary-layer equations.

D. W. Dunn, Canada

6771. Sakiadis, B. C., Boundary-layer behavior on continuous solid surfaces: Part 2, The boundary layer on a continuous flat surface, *AIChE J.* **7,** 2, 221–225, June 1961.

The laminar boundary layer on a moving flat surface in the case of zero free-stream velocity is investigated by numerical solution of the boundary-layer equations and also by an integral method. The two methods give results that are in close agreement. The corresponding turbulent boundary layer is investigated by the integral method. Comparison is made with the standard results for the boundary layer on a flat plate in a uniform stream.

D. W. Dunn, Canada

6772. Riley, N., An application of Mangler's transformation, *Quart. J. Mech. Appl. Math.* **14,** 2, 197–202, May 1961.

Axially symmetric, steady, boundary-layer flows are reduced to similar plane flows by the transformation. Solution is given for a circular jet hitting a coaxial body of revolution.

C. M. Ablow, USA

6773. Stroud, J. F., Effect of discontinuity in wall curvature on boundary layer, *ARS J.* **31,** 5, 664–665 (Tech. Notes), May 1961.

Combining the integral momentum equation with assumptions of small perturbations and a geometry consisting of a plane wall preceding a finite curvature surface, it is demonstrated that a change in the rate of momentum thickness growth depends upon the ratio of displacement thickness to radius of curvature and inversely to Mach number.

J. R. Baron, USA

6774. Soundranayagam, S., Boundary layer flow in water turbine blading and its effect on model similitude, *J. Mech. Engng. Sci.* **3,** 1, 32–36, Mar. 1961.

It is often assumed that the boundary layers in both model and prototype are turbulent and this allows simple formulas to be used for efficiency step up. While it has been almost certain that the boundary layers in the prototype are turbulent, no such assurance has existed with regard to model conditions. In this paper an attempt is made to define the state of the boundary layer on the turbine blades of prototype and model conditions.

It is shown that the model blades are hydraulically smooth while the full-size blades are hydraulically rough. The use of laminar profiles in water turbines is discussed and their susceptibility to cavitation pointed out. The possibility of laminar separation in model water turbines causing an increase in loss is discussed.

J. C. Geyer, USA

6775. Bhatnagar, P. L., On two-dimensional boundary layer in non-Newtonian fluids with constant coefficients of viscosity and cross-viscosity, *Proc. Indian Acad. Sci.* (*A*) **53,** 2, 95–97, Feb. 1961.

Author shows that the boundary-layer approximations for two-dimensional flows of incompressible non-Newtonian fluid with constant coefficients of viscosity and cross-viscosity reduce simply to those of Newtonian fluid on replacing the pressure by a suitably chosen expression.

G. Power, England

6776. Murzinov, I. N., Influence of laminar boundary layer on thin streamlined blunt cones in high supersonic flow (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 152–153, Jan./Feb. 1961.

6777. De Santo, D. F., and Keller, H. B., Numerical studies of transition from laminar to turbulent flow over a flat plate, AFOSR 723 (New York Univ., Coll. Engng. Res. Div.), 44 pp., Apr. 1961.

6778. Neal, B., The static and forward speed testing of a flapped wing with boundary layer control for use in deflecting propeller slipstreams downward for vertical take-off: Part 1, Nat. Res. Counc. Canada, Aero. Rep. LR-288, 20 pp. + figs., July 1960.

6779. Wissler, E. H., and Schechter, R. S., A further note on a diffusion problem with chemical reaction, *Appl. Scient. Res.* (*A*) **10,** 3/4, 198–204, 1961.

Chemical reaction in an isothermal laminar-flow tubular reactor is studied for the case of consecutive irreversible first-order reactions. Resulting differential equations are similar to famous Graetz problem. General solution is obtained and some numerical results are given.

M. Tribus, USA

6780. Secrest, D., and Hirschfelder, J. O., Slowly reacting gas mixture in a heat conductivity cell, *Physics of Fluids* **4,** 1, 61–73, Jan. 1961.

One-dimensional, steady-state, nonflow equations governing the species and energy conservation are formulated and solved for a reacting gaseous mixture bounded by a hot wall on one side and a cold wall on the other. Walls are assumed to be noncatalytic and isothermal. Finite, nonzero reaction rates are considered over a range of the ratio of reaction time to diffusion time, thereby embracing the regimes of chemical nonequilibrium. Numerical exact and analytical approximate solutions are presented for reaction times which are long, intermediate, and short compared with diffusion times. The hydrogen-iodine system is chosen for illustrative examples demonstrating the methods. Both the bimolecular and the atomic mechanisms are treated. Experiments which are suggested in connection with the theoretical work presented may be hampered by uncertainties in the catalytic efficiencies of wall materials for the various surface processes.

A. Q. Eschenroeder, USA

Turbulence

(See also Revs. 6709, 6720, 6733, 6797, 7007, 7008)

6781. Kennedy, D. A., and Corrsin, S., Spectral flatness factor and 'intermittency' in turbulence and in non-linear noise, *J. Fluid Mech.* **10,** 3, 366–370, May 1961.

The tendency toward intermittency of the higher wave number components of turbulence is studied by measurements of the flatness factor F. A band-passed turbulence signal is processed electronically and it is found that F increases with increasing central frequency. For the total signal $F = 3$, the value for a Gaussian distribution. Similar measurements are made on electronically produced Gaussian noise and on the squared Gaussian noise. It is found that F is constant for the Gaussian noise but increases with frequency for the non-Gaussian noise. For the latter total signal F is smaller than for the band-passed signal.

A mathematical demonstration is presented showing that F for the differentiated squared Gaussian noise may be either greater or less than that for the undifferentiated signal.

W. D. Baines, Canada

6782. Butler, T., A mathematical example displaying features of turbulence, WADC TR 59-52 (ASTIA AD 213590), 68 pp., Mar. 1959.

The Navier-stokes' differential equations describing the movement of fluids concern the laminar flow. The complex phenomenon of turbulence cannot accurately be treated mathematically. Thus assumptions must be made which, while simplifying the computation, should not give a distorted idea of the actual turbulence. For an approximate mathematical display of turbulent flows E. Hopf has suggested a system of integral-differential equations which is comparatively simple and describes the behavior of turbulent flows.

This article quantitatively examines the Hopf method and the Hopf mathematical model of the turbulence on the basis of the probability theory. While this simplified method is found to reflect fairly well the characteristics of turbulence, it does not give an adequate mathematical description of some essential inherent features of the turbulent flow. M. Strscheletzky, Germany

6783. Bykov, V. M., The calculation of the starting length of a two-dimensional jet expanding in a restricted space (in Russian), *Nauchn. Dokl. Vyssh. Shkoly, Energetika* no. 1, 129–134, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7468.

The motion of a fluid in a two-dimensional duct with an abruptly expanding cross section, thus representing a breakaway diffuser flow with a developed circulation region, is investigated. Simulating the fluid motion in this case to that of a free, turbulent jet, the author makes an attempt to evaluate the magnitude of the starting length of the flow, which he defines as the minimum distance required "for transformation of the velocity profile from a practically uniform curve in the discharge cross section, to the developed forces characteristic for the expansion length of the flow".

An approximation formula is obtained, indicating that the distance of the starting length referred to the total expansion length of the flow (length of the circulation region) depends only on the degree of constriction of the duct. An experimental determination has been made of the numerical coefficient appearing in the above-mentioned formula. It must be pointed out, however, that, even in the absence of any explicit relationship between this coefficient and the degree of constriction of the duct, the accuracy of this determination leaves much to be desired.

O. V. Yakovlevskii
Courtesy Referativnyi Zhurnal, USSR

6784. Balashov, G. V., Turbulent jets in a medium at high temperature (in Russian), *Trudi Rostovsk. In-ta Inzh. Zh.-D. Transp.* no. 21, 156–70, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7469.

Results are presented of an experimental investigation into the expansion of a cold, axially-symmetrical, turbulent air flow in a gaseous (combustion products) medium at a high temperature. The flow of air at room temperature issues with a velocity of 50-70 m/sec, from a nozzle with a diameter of 500 mm and a length of 2000 mm. Into the same space products of combustion are introduced, raising the ambient temperature to 530–980 °.

The experimental results are presented in the form of velocity and temperature fields, measured in different cross sections of the jet. It is demonstrated experimentally that, in the case of a cold jet, the change in the axial distribution of the excess temperature is less than in the case of a high-temperature jet.

Note should be taken of the satisfactory agreement between the experimental results and the analytical results for nonisothermal turbulent jets. V. Ya. Borodachev
Courtesy Referativnyi Zhurnal, USSR

6785. Eagleson, P. S., Huval, C. J., and Perkins, F. E., Turbulence in the early wake of a fixed flat plate, Mass. Inst. Technol., Hydrodynamics Lab., Dept. Div. Sanitary Engng. TR 46, 67 pp., Feb. 1961.

6786. Hersch, M., Experimental method of measuring intensity of turbulence in a rocket chamber, *ARS J.* **31,** 1, 39–45, Jan. 1961.

Intensity of turbulence in a rocket chamber is determined photographically from the gas jet spreading in the combustion chamber. The results indicate that the intensity of turbulence is relatively high near the injector but diminishes downstream. Changes of several operating parameters have little effect upon intensity of turbulence. M. Kataoka, Japan

Aerodynamics

(See also Revs. 6508, 6739, 6742, 6743, 6745, 6747, 6753, 6762, 6764, 6773, 6778, 6796, 6828, 6835, 6839, 6973, 7013)

6787. Hunziker, R. R., On the calculation of the minimum wave plus vortex drag of supersonic wings (in English), *ZAMP* **11,** 6, 504–508, Nov. 1960.

The problem of the supersonic wing of given planform and lift for minimum wave-plus-vortex drag was formulated as a mixed harmonic problem in a plane by E. W. Graham [Douglas Aircraft Co. Inc., Rep. no. SM-22666, Dec. 1956] and by A. A. Nikolsky and M. N. Kogan [See, for example, Yoshihara, Kainer, and Strand, *J. Aero. Sci.* **25,** 473–479, 496, 1958; AMR **12**(1959), Rev. 1960]. Here a solution is proposed involving mapping of the pertinent domain (enclosed by the projection of front and rear Mach envelopes on a transverse plane) on the exterior of a circle, for example by Theodorsen's method [NACA Rep. 452 (1934)]. One result is an expression for the optimum drag coefficient. It is proposed that the procedure be programmed for a high-speed computer. A theoretical advantage over the procedure suggested in the cited paper by Yoshihara et al is pointed out.

W. R. Sears, USA

6788. Lisunov, A. D., On the theory of unsteady supersonic gas flow about a wing of finite span, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 1, 230–232, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N. Y.)

Applying results of three-dimensional thin wing theory and using an exponential differential operator, author obtains the velocity potential in the form of a double series whose terms correspond to the steady, quasi-steady, and periodic motion cases. The method can be used to determine the aerodynamic forces resulting from an arbitrary disturbance on an elastic wing of finite span.

The application to the case of an elastic wing encountering an arbitrary spatial vertical gust is outlined.

W. Fiszdon, Poland

6789. Ackermann, U., and Bock, G., Consideration of a two-vortex wing model (in German), *Z. Flugwiss.* **9,** 4/5, 100–104, Apr./May 1961.

A method is developed by which it is possible to compute lift and moment coefficients of thin airfoils in ground effect, by representing the airfoil by two vortices only. Comparison with lifting-surface theory shows very good agreement to exist for small angles of attack in general and for large angles of attack when the distance between the airfoil and the ground is larger than half the chord length. The method, because of its relative simplicity, may prove useful in the prediction of lift and moment coefficients of low-aspect-ratio wings in ground effect.

J. Roskam, USA

6790. Peterson, V. L., and Menees, G. P., Aerodynamic loads at Mach numbers from 0.70 to 2.22 on an airplane model having a wing and canard of triangular plan form and either single or twin vertical tails, NASA TN D-690, 57 pp., June 1961.

Results of an investigation of the aerodynamic loads on a canard airplane model are presented without detailed analysis for the Mach number range of 0.70 to 2.22. The model consisted of a triangular wing and canard of aspect ratio 2 mounted on a Sears-Haack body of fineness ratio 12.5 and either a single body-mounted vertical tail or twin wing-mounted vertical tails of low aspect ratio and sweptback planform. The body, right wing panel, single vertical tail, and left twin vertical tail were instrumented for measuring pressures. Data were obtained for angles of attack ranging from -4° to $+16^\circ$, nominal canard deflection angles of 0° and 10°, and angles of sideslip of 0° and 5.3°. The Reynolds number was 2.9×10^6 based on the wing mean aerodynamic chord. Selected portions of the data are presented in graphical form and attention is directed to some of the results of the investigation. All of the experimental results have been tabulated in the form of pressure coefficients and integrations of the pressure coefficients and are available as supplements to this paper. A brief summary of the contents of the tabular material is given.

From authors' summary

6791. Mugler, J. P., Jr., and Olstad, W. B., Static longitudinal aerodynamic characteristics at transonic speeds of a blunted right triangular pyramidal lifting reentry configuration for angles of attack up to 110°, NASA TN D-797, 38 pp., June 1961.

The static longitudinal aerodynamic characteristics of a blunted right triangular pyramidal lifting reentry configuration have been obtained at Mach numbers from 0.60 to 1.20 and angles of attack from 0° to 110°. The test Reynolds number, based on the mean geometric chord, varied during the tests from about 2.2×10^6 to 5.7×10^6.

The results indicate that the model was statically longitudinally stable near 0° and 90° angle of attack; however, the onset of pitch-up caused unstable or neutrally stable regions between angles of attack of about 25° to 50°. Maximum lift-drag ratios of about 2.4 were obtained at subsonic speeds and then diminished to about 1.6 at low supersonic speeds. Comparisons with data from other tests indicate that blunting the nose, leading edge, and ridge line had little effect on the maximum lift-drag ratio.

From authors' summary

6792. Stanisic, M. M., Concerning the integral equation of unsteady motion of a delta wing in supersonic flight by means of the acceleration-potential method, *J. Aerospace Sci.* **28,** 4, 343–345 (Readers' Forum), Apr. 1961.

By development in powers of reduced frequency, the equation is reduced to a series of integral equations of the steady flow type. A development of this note appears as *ZAMM* **40,** 9, 397–414, Sept. 1960 [AMR **14**(1961), Rev. 3726].

J. P. Guiraud, France

6793. Grunwald, K. J., Aerodynamic characteristics of a four-propeller tilt-wing VTOL model with twin vertical tails, including effects of ground proximity, NASA TN D-901, 137 pp., June 1961.

Results are presented of a wind-tunnel investigation of the aerodynamic stability, control, and performance characteristics of a model of a four-propeller tilt-wing VTOL airplane employing flaps and speed brakes through the transition speed range. The results indicate that the wing was stalled for steady level flight for all conditions of the investigation; however, the flapped configuration did produce a higher maximum lift. The effectiveness of the flap in delaying the stall in the present investigation was not as great as in some previous investigations because the flap used was smaller than that used previously. The wing stall resulted in an appreciable reduction of aileron effectiveness during the transition. Out of ground effect the low horizontal tail did not appear to be in an adverse flow field as had been expected and showed no erratic changes in effectiveness; however, in ground effect a large nose-down moment was experienced by the model. In general, the lateral aerodynamic data indicate that the configuration is directionally stable and possesses positive dihedral effect throughout the transition, and the data show no signs of erratic flow at the vertical tails.

From author's summary

6794. Paulson, J. W., and Shanks, R. E., Investigation of low-subsonic flight characteristics of a model of a hypersonic boost-glide configuration having a 78° delta wing, NASA TN D-894, 31 pp., May 1961.

Flight tests were made over an angle-of-attack range from 10° to 35° with and without artificial pitch and roll damping added. Force tests were made from -4° to 40° angle of attack to determine the static stability and control characteristics and from 0° to 30° angle of attack to determine the dynamic stability derivatives.

From authors' summary

6795. Spearman, M. L., Aerodynamic characteristics in pitch of a series of cruciform-wing missiles with canard controls at a Mach number of 2.01, NASA TN D-839, 40 pp., May 1961.

The investigation was conducted in the Langley 4- by 4-ft supersonic pressure tunnel. The missiles had cruciform wings and canard surfaces of delta planform with 70° swept leading edges. Five models were tested with fineness ratios varying from 19.1 to 14.8. The tests covered an angle-of-attack range up to about 28° for the complete configuration and various combinations of component parts.

From author's summary

6796. Ryhming, I. L., and Yoler, Y. A., Supersonic boom of wing-body configurations, *J. Aerospace Sci.* **28,** 4, 313–320, Apr. 1961.

The supersonic boom of a lifting wing-body configuration in level flight is investigated by considering equivalent bodies of revolution replacing the effects of body volume, wing volume, and lift. The author deduced that the boom due to lift can be suppressed by aerodynamic interference. When the boom due to lift is much larger than the boom due to volume, such interference is shown to be ineffective. The theoretical conclusions are compared with wind-tunnel experiments.

G. V. R. Rao, USA

6797. Ludford, G. S. S., Longitudinal vortices in shear flow (in English), *ZAMM* **41,** 4, 153–158, Apr. 1961.

Under certain conditions, approximately streamwise vortices may exist close to wall. Paper gives mathematical description of case of single vortex in main shear flow (neglecting viscosity). Case studied in most detail is when original flow, before superposition of vortex, has linear velocity profile with velocity dependent only on distance from wall, and assumes that vortex axis is constant distance a from wall. Author then shows that effect of vortex is to form "tunnel" below boundary layer, which is lifted to maximum distance of $2.06a$ from wall; interesting conclusion is that disturbance due to vortex is independent of its strength. Details of flow within tunnel are indeterminate from this analysis. For this case ($U = kz$) tunnel is of infinite transverse extent but for $U = k(z + z_0)$ tunnel is closed transversely, boundary layer remaining attached to wall on each side of tunnel. Vortex is inclined at small angle to direction of undisturbed flow, tendency to move being cancelled by effect of its image in wall. Paper concludes with conjectures regarding effects of plurality of vortices.

Paper represents interesting first study of this phenomenon of interest in effects of e.g. excrescences. Would be interesting to see follow-up considering nonlinear velocity profiles (especially those exhibiting instability?).

A. E. Brock, England

Vibration and Wave Motion in Fluids

(See also Revs. 6744, 6792, 6895, 6900, 6908, 6932, 6965, 6967, 6970, 6971, 7013, 7014, 7015, 7016)

6798. Longuet-Higgins, M. S., and Stewart, R. W., The changes in amplitude of short gravity waves on steady non-uniform currents, *J. Fluid Mech.* **10**, 4, 529–549, June 1961.

The common assumption that the energy of waves on a nonuniform current U is propagated with a velocity $(U\ c_g)$ where c_g is the group velocity, and that no further interaction takes place, is shown to be incorrect. In the present paper asymptotic solutions for the combined velocity potential are obtained for the simple case when the nonuniform current U is compensated by a vertical upwelling from below.... In the second example the current on the x-axis is assumed to be as in the first case, but the horizontal variation in U is compensated by a small horizontal inflow from the sides.... From these two cases a general law of interaction between short waves and nonuniform currents is inferred. This is then applied to a third example when waves encounter a current with vertical axis of shear, at an oblique angle. The change in wave amplitude is shown to differ from the previously accepted value.

The conclusion that nonlinear interactions affect the amplification of the waves has some bearing on the theoretical efficiency of hydraulic and pneumatic breakwaters.

From authors' summary by D. Boyanovitch, USA

6799. Le Mehaute, B., Periodical gravity wave on a discontinuity, *Proc. Amer. Soc. Civ. Engrs.* **86**, HY 9 (*J. Hydr. Div.*), 11–41, Nov. 1960.

A general theory is presented to study the transmission and reflection of gravity waves on a discontinuity to the first order of approximation.

Particular attention is given to the case of an obstruction, a change of width and a change of depth. In the latter case only, the gravity wave arriving at an angle is studied.

From author's summary by G. H. Lean, England

6800. Goren, S. L., and Gavis, J., Transverse wave motion on a thin capillary jet of a viscoelastic liquid, *Physics of Fluids* **4**, 5, 575–579, May 1961.

Axial tensile stresses and their rate of relaxation developed in a viscoelastic jet after ejection from a nozzle can be studied by analyzing the wave pattern imposed on the jet by transverse oscillations of the nozzle. Neglecting effects of rigidity and viscosity, a theory for transverse vibrations of the jet is developed by quasi-one-dimensional stream-tube analysis. Special solutions are given for constant tensile stress and stress decaying exponentially from a maximum value at the nozzle exit to a constant value. In the second case it is assumed that $T_0/\rho u_1^2 \ll 1$ (T_0 = tensile stress at the nozzle exit, u_1 = average velocity of the jet, ρ = density).

The resulting wave pattern is a superposition of standing and traveling waves, whose features are discussed in some detail.

E. Becker, Germany

6801. Le Mehaute, B., Theory of wave agitation in a harbor, *Proc. Amer. Soc. Civ. Engrs.* **87**, HY 2 (*J. Hydr. Div.*), 31–50, Mar. 1961.

A harbor is considered as a combination of discontinuities in series, terminated by a beach that may dissipate a part of the incident energy. The motion in each section is treated as unidirectional; the effect of each section is treated as unidirectional; the effect of each discontinuity is represented by complex coefficients of transmission and reflection which are obtained from a rough theory published in an earlier paper. (No attempt is made to solve the potential problem.) Experiments are presented which agree with the theory better than might have been expected, particularly near a resonance.

F. Ursell, England

6802. Nakamura, K., Motion of water due to long waves in a rectangular bay of uniform depth, *Sci. Rep. Tohoku Univ. Japan (Fifth Series-Geophysics)* **12**, 3, 191–213, Mar. 1961.

The wave height at the head of a rectangular bay of uniform depth is investigated when a packet of sinusoidal long waves is incident upon the bay mouth. It is assumed that no energy is dissipated in the form of diverging waves from the bay mouth, and the bay water possesses eddy viscosity. The bay head is assumed to be either a rigid or nonrigid wall.

The expression for the wave height is given by two solutions, the mode solution and the ray solution. For the case of a nonviscous wave motion with a rigid wall, response curves, which represent the maximum wave height at the bay head..., are obtained.... The latter may be useful in estimating the wave height due to tidal waves at the bay head.

From author's summary by D. Boyanovitch, USA

6803. Macagno, E. O., and Macagno, Matilde, Kinetic energy of a liquid surrounding a prolate spheroid vibrating at its free surface, *J. Ship Res.* **4**, 4, 29–36, Mar. 1961.

An approximate expression for kinetic energy due to horizontally vibrating spheroid is possible under the assumptions of "strip theory." Authors have derived an exact expression for the case of horizontal vibrations with any number of nodes and worked out correction factors to be applied to values from approximate method for practical application in ship design. The expression has been used to analyze in detail two particular cases with two and three nodes. These results have been compared with those due to vertical vibrations which were published previously.

P. Franke, Germany

6804. Laird, A. D. K., Johnson, C. A., and Walker, R. W., Water forces on accelerated cylinders, *Trans. Amer. Soc. Civ. Engrs.* **125**, 1, 652–666, 1960.

The measured total resistance of a cylinder (length-to-diameter ratio 9, 17 and 31) is split up into a drag and an inertia force. The latter is estimated by assuming the virtual mass to be that of an infinite cylinder in potential flow. Then the instantaneous drag coefficients agree with the values for uniform motion at the same Reynolds number (test range 0.3×10^5 to 3×10^5) except for some cases of deceleration. (To study details of such cases, presumably, the concept of a virtual mass independent of the velocity is no longer good enough to describe flows in real fluids with irreversible vorticity production.)

K. Wieghardt, Germany

6805. Roy, S. K., On the use of perturbation solutions for decay laws in fluid mass oscillations in a non-linear dissipative system, Proceedings of the Symposium on Non-Linear Physical Problems, Univ. of Roorkee, Roorkee, India, Dec. 21–22, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., S.69–S.78.

Perturbation solutions are of considerable importance in obtaining useful decay laws in closed form for nonlinear problems, which otherwise would have to be treated by numerical methods. The decay law deduced is considered both for oscillations of a system with one degree of freedom, and also for two degrees of freedom with weak interaction. In both cases the law of decay as well as the dependence of the decay constants on the physical characteristics of the system compare well with typical observations.

From author's summary by J. N. Hunt, England

6806. Wallace, F. J., Pulsation damping systems for large reciprocating compressors and free-piston gas generators, Instn. Mech. Engrs., Prepr., 24 pp., 1960.

Paper is concerned with intake systems involving individual damping system for each gas generator and common ducting system for group of gas generators from which the individual damping systems draw. Analysis is limited to individual damping systems and is based on mechanical vibration theory. Equivalent electrical systems are also mentioned.

Object of analysis was to facilitate calculation of optimum dimensions when given permissible pressure drop, pulsation amplitude and form of suction pulse. Results are confirmed by a substantial body of experimental work.

From author's summary by R. A. A. Bryant, Australia

6807. Forwald, H., Wave phenomena in compressed-air ducts, *ASEA Res., Sweden* no. 5, 149 pp., 1960.

Booklet presents many results of well-designed experiments on transient pressures during filling discharge of 2-in. and 3-in. diam., 3–11m long ducts with air at 16 atm, which form welcome addition to otherwise well-studied area of compression wave phenomena. Results of presented theoretical treatment of plane wave fronts, assuming absence of losses, agree well as long as time lapse after initiation is short, i.e. when friction and turbulence have not yet exerted much influence. Results are immediately applicable to design of air-blast circuit breakers.

G. H. Toebes, USA

6808. Palishkin, N. A., Analytical methods for calculating surge tanks and standpipes in the presence of (hydraulic) resistance, and their analysis (in Russian), *Izv. Vyssb. Uchebn. Zavedenii: Energetika* no. 8, 121–126, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 7652.

A comparison is made between Prazvil's rigorous equation for the first amplitude of oscillation of the level in a surge tank during the complete shedding of the load and various approximation formulas; also with approximate formulas for the first amplitude during application of the load. The range of application of these approximate formulas is indicated. N. A. Kartvelishvili

Courtesy Referativnyi Zhurnal, USSR

6809. Logvinov, N. G., An investigation of the pressure fluctuations in mine air circuits supplied by piston compressors (in Russian), *Trudi Donetsk. Industr. In-ta* **26**, 3–24, 1958; *Ref. Zb. Mekb.* no. 7, 1959, Rev. 7473.

A solution is presented for the problem of the pressure fluctuations in an air-flow along an extensive ventilating duct if at the one end the flow volume is constant and, at the other end, fluctuates according to a periodic law. The flow is assumed to be isothermal. The resistance values of the air duct, established for the steady state, are transformed to apply to the unsteady state.

The resulting analytical solution has been verified experimentally, in laboratory and full-scale conditions. The tests were made with inertialess pressure gages, the indications whereof were recorded oscillographically.

The experiments have shown that the fading of the oscillations in the air duct is in fact more intensive than was to be expected from the analytical solution. V. D. Sokolov

Courtesy Referativnyi Zhurnal, USSR

Fluid Machinery

(See also Revs. 6505, 6512, 6774, 6886, 6900, 7024, 7025, 7026)

6810. Miller, Genevieve R., Lewis, G. W., Jr., and Hartmann, M. J., Shock losses in transonic compressor blade rows, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 235–242, July 1961.

The purpose of this paper is to increase the understanding of the loss phenomena in transonic compressors and to predict them quantitatively. The losses as measured in transonic compressors cannot be correlated by the diffusion factor and the relative Mach number in the front of the blade row alone. However, if a bow shock in front of the blades with a realistic variation of the Mach number along this shock is considered, good correlation between measured and calculated losses is obtained. For this flow model the shock strength increases from the position in front of the leading edge to the suction side of the blades. Therefore the losses due to shock increase over the passage between the blades from the pressure side of the blades to the suction side. This is in quantitive agreement with the measured losses in a rotating cascade.

Measurements are also presented which indicate good agreement between the actual position of the shock and the position assumed in this flow model. The reviewer finds that this paper is informative and very clearly written.

H. P. Eichenberger, USA

6811. Bullock, R. O., Critical high lights in the development of the transonic compressor, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 243–257, July 1961.

This is a summary of the work done at NASA for the purpose of advancing the knowledge in the design of transonic axial flow compressors.

First the technical reasons which favor the transonic compressors as compared to the subsonic and supersonic compressors are given. Then the NACA result on transonic single-stage compressors is described in detail: blade shapes, operating range and results are given in such detail that this paper gives a very good orientation without reading the 28 references quoted. Blade element characteristics obtained by tests are given for one specific example and the losses obtained in a large number of compressors are correlated. It may be concluded that transonic compressors can now be designed with confidence using the NACA data. The compressors have at least as good efficiency as the subsonic compressors (about 90% stage efficiency with typical 1.4 pressure ratio), wide operating range, and no more sensitivity to nonuniform inlet flow than the subsonic compressors, but these compressors are more sensitive to incorrect design or to dimensional aberration from correct design.

Reviewer finds that this is a good summary about work which may fill with pride all those who contributed.

H. P. Eichenberger, USA

6812. Klapproth, J. F., A review of supersonic compressor development, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 258–268, July 1961.

This paper reviews and summarizes the essential results of 15 years' work on supersonic compressors, both at NACA and elsewhere. First the geometry and factors such as blade loading of 13 tested designs are summarized in a table. It is found that a complete departure from standard subsonic design practice was used in the sense that unjustifiably optimistic blade loading either in the rotor or stator was assumed. After discussing analytical flow patterns (such as external shocks, internal shocks, and fully supersonic flow, and radial equilibrium considerations), typical operational experience is presented: shock in rotor-type compressors reached typically between 75 to 84% efficiency at a pressure ratio slightly above 2; fully supersonic rotors showed very high losses in the stators leading to typical efficiencies of 75% at a pressure ratio of 3.6. The author finds that compressor design using loadings which will not lead to separation will lead to pressure ratios attainable by transonic compressors. He proposes then to design for controlled separation which leads to high pres-

sure ratio and acceptable efficiencies (85%). Fifty-three references are quoted.

The reviewer finds that this paper is based on unusually broad and accurate knowledge of this subject.

H. P. Eichenberger, USA

6813. Savage, M., Boxer, E., and Erwin, J. R., Resume of compressor research at the NACA Langley Laboratory, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 269–285, July 1961.

This paper describes the compressor research of NACA–Langley. High-speed cascade tests have been conducted. It was found that blades having the loading and the maximum thickness further back than the NACA 65-series performed much better than the latter at Mach numbers as high as 1.4. Soon thereafter this test facility was sent to the NATO training center in Brussels.

Tests with rotors showed improvements as suggested by cascade tests. A typical rotor with a Mach number of 1.08 at the tip had a pressure ratio of 1.38 with an efficiency of 91%.

The supersonic compressor research was not based on cascade tests but followed the concepts of supersonic diffusers. With shocks in the rotor a maximum rotor efficiency of 84% at a pressure ratio 2.20 was obtained with extremely thin blades. Efficiency improvement through external compression before the normal shock in the rotor could not be realized. In a fully supersonic rotor a pressure ratio of 7.2 at 90% efficiency at 1450 ft/s tip speed was achieved. Its destruction prevented its testing together with a stator in which the pressure recovery of the kinetic energy would be achieved.

In the two final pages, the combination of supersonic axial inlet and compressor is discussed. In a compressor with supersonic axial inlet velocity, shock in rotor may lead to systems improvement even if the compressor efficiency is low, since it fulfills in part the function of efficient inlet pressure recovery. Fifty-one references are quoted.

H. P. Eichenberger, USA

6814. Wichert, K. E., Some investigations into transonic axial-flow compressors with high stage load coefficients and low degrees of reaction, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 286–290, July 1961.

Author compares three designs of SNECMA: (1) a subsonic multi-stage compressor, (2) subsonic first stages with transonic last stage, and (3) single-stage transonic compressor using a subsonic rotor and a supersonic entry to the stator. Some test results are given. An efficiency of 93% is quoted but it is not clear to this reviewer to what pressure ratio this relates.

H. P. Eichenberger, USA

6815. King, J. A., The J83 seven-stage transonic compressor, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 291–302, July 1961.

The seven-stage compressor design of the J-83 (2000-lb thrust, 295-lb weight and an sfc of 0.88 lb/lb thrust at sea-level) is described in detail in terms of all relevant design parameters such as velocities, angles, Mach number, pressure ratios, work inputs. Diffusion factors in each stage, blade geometry, incidence and deviation angle are discussed. The chord of the first stage was chosen for a Reynolds number of 200,000 at 40,000-ft altitude and a Mach number of 0.8.

The development of this compressor under the pressure of guaranteed performance and specified delivery time is described in detail. One of the first tests included all the seven stages and showed between 40 and 50% efficiency. Changes described in detail lead finally to the promised performance of 7:1 pressure ratio and 80% efficiency. The author finds that better matching of the stages could lead to an improvement of additional 5% in efficiency, but the Goose missile program for which this compressor was developed was cancelled and the J-83 was thereby terminated.

Reviewer finds that this is the most fascinating and instructive account of a compressor development published so far.

H. P. Eichenberger, USA

6816. Kovach, K., and Sandercock, D. M., Aerodynamic design and performance of five-stage transonic axial-flow compressor, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 303–321, July 1961.

The NACA five-stage transonic compressor is described in terms of design philosophy, geometry and performance.

The rotor blades consist of double circular arcs with an angle of incidence of 4° throughout. The over-all performance obtained by test was 80% efficiency at a pressure ratio of 5 and a maximum efficiency of 87% at 80% design speed and a pressure ratio of 3. The efficiency, temperature rise, and pressure ratio are given as a function of the flow rate at various speeds for each stage. An efficiency of 90% at a pressure ratio of 1.46 is typical for best flow rate.

Blade element characteristics (pressure ratio, efficiency, inlet Mach number, incidence angle deviation, diffusion factor, loss coefficients, etc.) are given for five sections for each rotor and stator. Design values are indicated for comparison. Mis-match of the stages impaired the performance at design point.

Reviewer finds that this paper together with the 28 references is a most useful contribution to transonic multi-stage axial flow compressor design.

H. P. Eichenberger, USA

6817. Swan, W. C., A practical method of predicting transonic-compressor performance, *ASME Trans.* **83** A (*J. Engng. Power*), 3, 322–330, July 1961.

A method for calculating the performance of a compressor stage is presented. The basis is (1) a correlation based on statistics of loss coefficients and a newly defined loading parameter valid at off design, (2) analysis of radial equilibrium (including streamline curvature). An IBM-650 needed 20 machine hours (IBM-704 about two hours) to produce a complete performance map using 20 stream filaments. A comparison with experiment shows close agreement of over-all stage performance (including stall line) and of the blade element data. This stage performance prediction method would form the basis of a multi-stage compressor design by the stage stacking method. In the discussion, Prof. Serovy suggests addition of casing and hub boundary-layer effects, especially for the calculation of multi-stage compressors.

H. P. Eichenberger, USA

6818. Provenzale, G. E., Losses in subsonic and transonic axial-flow compressors at optimum conditions, *J. Aerospace Sci.* **28**, 5, 431–432 (Readers' Forum), May 1961.

6819. Kurutz, I., The regulation of the radial flow impeller by adjusting the impeller blades (in English), *Acta Techn. Acad. Sci. Hungaricae, Budapest* **32**, 3/4, 415–422, 1961.

6820. Smith, V. J., Air circulator fans: a design method and experimental studies, Aero. Res. Lab. Melbourne, Austral. Rep. A. 119, 33 pp. + figs., Apr. 1960.

6821. Kull', A. M., and Laskin, A. S., An investigation of the influence of surface roughness on the characteristics of turbine blade cascades (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 193, 141–149, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7467.

The influence of five different types of roughness of a rotor cascade on blade losses therein is investigated. The mean height of the microprotuberances was varied between 3–100 microns, the coarser degrees of roughness being obtained by applying abrasive powders in a bakelite varnish, which very effectively simulates the form of surface roughening of steam-turbine rotor blades produced by saline deposits.

Three flow conditions are observed on roughened surfaces: aerodynamically smooth flow, a transition region, and a region of developed roughness. In the case of an aerodynamically smooth flow, increasing the relative roughness (ratio of the height of the microprotuberances to the length of the blade chord) from 0.07×10^{-3} to 0.25×10^{-3} (corresponding to Class 8–7 surface finish according to the GOST standard) practically does not influence blade losses. With further increasing roughness, corresponding to the transitional region (Class 6 surface finish), the losses abruptly increase, approximately proportionally to the increase in height of the protuberances; and, finally, in the region of developed roughness (Class 5–4 surfaces), the increase in the blade losses with increasing height of the protuberances is appreciably slower.

Investigations have shown that surface roughness materially influences the rate of change of the losses with the R number (Reynolds number) even in the qualitative sense. Initial turbulence of the flow likewise influences this rate.

The influence of location of the roughness areas along the blade contour, on the cascade losses, was also investigated.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

6822. Kulakov, V. M., The optimum blade number for turboblower rotors (in Russian), Issled. Protsessov i Mashin Glubokogo Kholoda (MVTU **75**), Moscow, Mashgiz, 1958, 48–61; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7497.

A change in the blade number z of a turboblower rotor has a dual effect on the pressure head: on the one hand, an increase in the number of blades reduces the loss of head ΔH_z due to the presence of axial vortices in the blade ducts of the rotor; on the other hand, the same number of blades increases the loss of head ΔH_b due to the increasing hydraulic losses by the friction of the working fluid on the blades. Consequently, determination of the optimum blade number is reduced to finding the minimum of the function

$$\Delta H_z + \Delta H_b = f(z)$$

A formula is given for determining the minimum value of the function $\Delta H_z + \Delta H_b$, depending on the blade number z.

For rotors of the pump type, the results calculated by this formula give as the optimum blade number $z = 10$–12; while for compressor-type rotors, the optimum is $z = 19$–23. This corresponds very closely with the blade numbers actually used in such rotors.

V. Kh. Abiants

Courtesy Referativnyi Zhurnal, USSR

6823. Cheprasov, V. P., The construction of the flow outside profiles and cascades of arbitrary form (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Aviats. Tekhn.* no. 2, 121–127, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7683.

For the approximate calculation of the potential flow without breakaway of an incompressible fluid around an isolated profile or cascade of profiles, the already known conformal representation on a circle of the periphery of the profiles or cascades of the type of S. A. Chaplygin's, most nearly approaching those to be calculated, is used. The determination of the coefficients of resolution of the required complex potential of the circulatory flow is reduced to the solution of a system of algebraic equations.

An example of a comparison between analytical and experimental results is given.

A similar method was described in 1951 by A. S. Ginevski [cf. S. A. Dovzhik: "Profiling the blades of a subsonic, axial compressor," Promyshlennaya aerodinamika, Oborongiz, 1958].

L. G. Naumova

Courtesy Referativnyi Zhurnal, USSR

6824. Likhterov, B. M., The selection of the principal calculation parameters of a stage in an axial compressor (in Russian), *Trudi Nauchno-Tekhn. O-va Sudostroit. Prom-sti* **8**, 1, 187–201, 1958; *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13374.

A general relation is obtained for the range of stable work and dimension of a compressor to the basic parameters of the stage (input coefficient, degree of reaction and relative pitch of the blades) which, when taken together with the known relations of the pressure and the economy of working of the stage to these parameters, enables a rational approach to be made to the problem of selecting the basic calculation parameters for the stage of an axial compressor. A detailed analysis is furnished regarding the influence of the basic calculation parameters of the stage on the pressure exercised by the stage, the efficiency (k.p.d.) of the compressor, the transverse dimensions of the compressor, the length of the stage in the axial direction and the length of the portion between the inlet and the outlet valves, and also on the range of stability of the work. Recommendations are given, on the basis of an analysis of the relations obtained, dealing with the selection of the basic parameters for the stage in relation to the requirements of the compressor (the minimum longitudinal or transverse dimensions, high rating for the economy of working or a wide range of stable work).

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR

6825. Ginevskii, A. S., Investigation of two schemes dealing with the change in area of the portion of the stage of an axial compressor situated between the inlet and the outlet valves (in Russian), *Prom. Aerodinamika* no. 10, 1958, 61–76; Moscow, Oborongiz, *Ref. Zh. Mekh.* no. 11, 1959, Rev. 13375.

Author investigates the influence of various ways of shortening the blades on the characteristics of the stage of an axial compressor. Results are given of the experimental investigation of nine working wheels at low velocities obtained from the initial wheel, with an axial inlet for the flow, calculation values for the input coefficient of $C_a = 0.55$, for the coefficient of pressure $N = 0.247$ and a relative radius for the hub of $r_0 = 0.5$. In the first series of wheels with $r = 0.6$, 0.7, 0.8 and 0.9 an elimination was carried out of the root sections (the diameter of the hub was increased) by filling up the interceiling ducts with insertion pieces. In the second series with $r = 0.547$, 0.6, 0.667 and 0.8 a progressive blunting off of the peripheral portions of the blades was taken in hand. A theoretical calculation was made of the characteristics on the assumptions of the truth of the hypothesis of cylindrical sections, the linear relation of the tangent of the angle of the flow's outlet to the tangent of the angle of inlet and the absence of losses. With these assumptions in operation, the theoretical relations of the magnitude N_T to c_a (the magnitude being the mean along the blades) are linear; an increase in the relative radius of the bulb results in an increase in the steepness of the characteristics if the root sections are excluded but shows a decrease if the peripheral sections are excluded. The experimental characteristics obtained agree satisfactorily with the theoretical.

G. Yu Stepanov

Courtesy Referativnyi Zhurnal, USSR

6826. Ovchinnikov, O. N., Lifting forces on the profile of a cascade in nonuniform flow (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 146–149, Jan./Feb. 1961.

6827. Linhardt, H. D., and Silvern, D. H., Analysis of partial admission axial impulse turbines, *ARS J.* **31**, 3, 297–308, Mar. 1961.

Contributions to total power loss of single-stage and re-entry partial admission impulse turbines based on one-dimensional flow theory are described. Empirical results are quoted for effects of partial admission, disc friction, pumping loss, Mach number, etc., but not Reynolds number. Resulting expression for stage efficiency is evaluated in terms of specific speed and a parameter not

in common use, the specific diameter. In accordance with hydraulic practice neither of these groups is dimensionless. Extensive computations show that partial admission turbines should employ many blades with small ratio of blade height to rotor diameter in contrast to the practice for full admission turbines and, further, that appreciable gains over published performance figures for high pressure ratio turbines can be realized by proportioning blade passages in accordance with results of analysis. Test results generally confirm these findings. Effect of interstage leakage was investigated for re-entry turbine and incorporated into similar computations. Test results are in acceptable agreement with analysis. Paper is a useful summary of current small-turbine practice but is not written too clearly.

A. J. Acosta, USA

6828. Horlock, J. H., Losses and efficiencies in axial-flow turbines, *Inter. J. Mech. Sci.* **2,** 1/2, 48–75, Oct. 1960.

This paper sets out to correlate the available data on losses in steam and gas turbines which are normally quoted in terms of very different parameters. By using a common nomenclature, the relationships between the different coefficients and efficiencies are clearly indicated. The main part of the paper compares a number of experimental correlations and shows the relatively small importance of Mach number and the increase in losses when the Reynolds number based on hydraulic diameter falls below 10^5. Unfortunate errors in Fig. 1 make some definitions hard to follow; C_{θ_2} is made equal to U instead of $U + W_{\theta_2}$, and after rotor, relative velocity is W_3, not W_2.

Paper is to be commended for its clear explanation of different loss parameters.

S. R. Montgomery, England

Flow and Flight Test Techniques and Measurements

(See also Revs. 6709, 6735, 7013)

6829. Livingstone, D. D., Flow measurement for accounting purposes, *ASME Trans.* **83** D (*J. Basic Engng.*), 2, 299–304, June 1961.

Tolerance in metering of 21 gaseous and fluid supply flows to petrochemical plant by thin-plate orifices is shown to be less than 1% on a yearly basis, provided certain installation, measurement and maintenance practices are adhered to. Main tolerance is then found in flow coefficient value as published in ASME Research Report on Fluid Mechanics. Results are based on statistical evaluation of 4-year records.

G. H. Toebes, USA

6830. Hall, D. A., and Atkins, W. W., New technique for measuring the velocity of high-speed objects, *J. Soc. Mot. Pic. Telev. Engrs.* **70,** 8, 634–636, Aug. 1961.

A new technique for the velocity measurement of controlled trajectory particles, projectiles, models or other objects has been developed for laboratory use in the study of ballistic phenomena. One principal advantage of this system is that the velocity of individual objects throughout a wide velocity spectrum can be measured for any given firing of the accelerator. The system employs a standard Fastax streak camera for film transport. Collimated light fields are placed along the trajectory through which the projectile or particle will pass. A narrow vertical slit, near and perpendicular to the trajectory, provides a submicrosecond shutter when image demagnification times rate of film travel equals or approaches the object velocity. A series of mirrors rotates the slit image 90°, enabling the light field to produce a ribbonlike exposure along the entire length of film. A projectile entering the light field creates an instantaneous shadow at the slit and is recorded as such on the film. This is repeated at two or more carefully spaced stations along the trajectory. With the projectile images and time-base markers produced simultaneously, it is necessary only to measure image displacement and determine rate of film travel to calculate object velocity.

From authors' summary

6831. Staritski, V. G., The degree of error in the measurement of the velocity of an unsteady flow (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 193, 60–65, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7895.

The problem is investigated of the degree of error introduced by periodic unsteadiness of a flow in the measurement of velocities by static heads in the vicinity of the running rotor of a turbomachine. This unsteadiness is caused by the fact that when the rotor is running in front of a static tube, vortex trails are discharged from the rotor blades with a frequency depending on the blade number and running speed of the rotor. A mathematical analysis is made of the causes of error and numerical values are given for the correction terms to be introduced in the expression for calculating the flow velocity behind the rotor, for three variants of an ideal, inhomogeneous pressure field behind the rotor. Examples are given of estimated values of the possible error in determining the flow velocity.

It should be observed that, in dealing with the history of the problem, author omits to mention the very first published papers devoted to analyzing the errors involved in the use of stationary pressure heads to measure the unsteady flow behind the rotor of a turbomachine, by K. A. Ushakov and Yu. A. Korostelev.

B. S. Dorogov
Courtesy Referativnyi Zhurnal, USSR

6832. Miesse, C. C., and Curth, O. E., How to select a flowmeter, *Prod. Engng.* **32,** 19, 35–46, May 1961.

6833. Clausen, D. F., A generator of stable smoke, *J. Aerospace Sci.* **28,** 7, p. 587 (Readers' Forum), July 1961.

6834. Kharikov, G. P., An investigation of the viscoelastic properties of binders during the process of setting (in Azerb.), *Elmi. Esserler. Azerb. Univ.* no. 5, 25–38, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7890.

An experimental arrangement is described enabling the investigation by high-speed cinematography of the kinetics of the immersion of solid bodies in viscoelastic media.

Expressions are presented relating the depth of immersion to the time-rate of descent of a Vicat needle.

From author's summary
Courtesy Referativnyi Zhurnal, USSR

6835. Runckel, J. F., and Lee, E. E., Jr., Investigation at transonic speeds of the loading over a 45° sweptback wing having an aspect ratio of 3, a taper ratio of 0.2, and NACA 65A004 airfoil sections, NASA TN D–712, 93 pp., May 1961.

An investigation at transonic speeds of the loading over a 45° sweptback wing having an aspect ratio of 3, a taper ratio of 0.2, and NACA 65A004 airfoil sections has been conducted in the Langley 16-ft transonic tunnel. Pressure measurements on the wing-body combination were obtained at angles of attack from 0° to 26° at Mach numbers from 0.80 to 0.98 and at angles of attack from 0° to about 12° at Mach numbers from 1.00 to 1.05. Reynolds number, based on the wing mean aerodynamic chord, varied from 7×10^6 to 8.5×10^6 over the test Mach number range.

Results of the investigation indicate that a highly swept shock orginates at the juncture of the wing leading edge and the body at moderate angles of attack and has a large influence on the loading

over the inboard wing sections. The chordwise position of the wing center of pressure shifted from about 43 per cent of the mean aerodynamic chord at a Mach number of 0.80 to about 53 per cent of the mean aerodynamic chord at a Mach number of 1.05. The lateral position of the center of pressure shifted outboard a maximum of about 4 per cent of the semispan over the same Mach number range.

From authors' summary

6836. Roberts, A. K., Design of the recoil system for the 4" × 7" hypersonic shock tube, Univ. Toronto, Inst. Aerophys. TN 42, 24 pp. + tables and charts, Oct. 1960.

Various arrangements for absorbing the recoil of large hypersonic shock tubes are discussed and reasons are given for the choice of a particular configuration. The recoil loads are calculated by the construction of wave diagrams of the flow by the method of characteristics. It is assumed that the gases are perfect and inviscid. The recoil damping is by liquid springs and these are described briefly. G. A. Bird, Australia

6837. Johnson, R. H., Hypersonic viscous effects in wind tunnels, *ARS J.* **31,** 7, 1022–1024 (Tech. Notes), July 1961.

Some strong influences of fluid viscosity on Mach 30 operation of a low density helium tunnel are described. Thick boundary layers characteristic of this flow not only change with pressure level, but they are affected by model and passage geometry so that: (1) Model shock-wave strength and shape affect the test section flow, necessitating the use of calibrating impact probes with the same shape as the model to be studied; and (2) these thick boundary layers are utilized in "viscous contouring" in a conical nozzle; i.e., uniform test section flow is achieved without the use of contoured nozzles. From author's summary

6838. Daen, J., and de Boer, P. C. T., Some studies on argon, helium and carbon dioxide with an integrated-schlieren instrumented shock tube, AFOSR 139 (Univ. Maryland, Inst. Fluid Dynam. Appl. Math. TN BN-225), 29 pp. + tables and charts, Dec. 1960.

6839. Kirk, D. B., A method for obtaining the nonlinear aerodynamic stability characteristics of bodies of revolution from free-flight tests, NASA TN D-780, 47 pp., Mar. 1961.

Method is presented for determining from free-flight tests of bodies of revolution the variation of pitching moment coefficient with angle of attack when motion is assumed to be nearly planar. Polynomial approximations in angle of attack form basis of method most successfully, being 1-3-5 in an example based on data obtained from free-flight wind tunnel tests. For given polynomial the ratio of the actual angle of attack to an equivalent "linear theory angle of attack" is theoretically deduced. From flight tests a "linear pitching moment coefficient" is calculated for test angle of attack and minimum number of test points (2 or 3) fitted to appropriate polynomial by simple iterative process employing "linear theory angle of attack."

Method compares favorably with two other methods which are illustrated. R. D. Milne, England

6840. Coupry, G., Determination of vibration modes of an aircraft in flight (in French), *Bull. Assn. Tech. Marit. Aero.* no. 60, 311–326, 1960.

Author describes flight tests with a twin-engined aircraft, the wing of which was vibrated by means of exciting equipment; normal accelerations were measured at 11 stations of the wing. It was tried—by a least squares procedure—to verify whether the deformations measured in flight could be represented by a linear combination of a limited number of vibration modes as measured at the ground, thus investigating the reliability of the assumptions normally adopted in flutter calculations.

It was concluded that the results—at least in the case of the test aircraft—confirm the said assumptions satisfactorily.

J. Buhrman, Holland

6841. Kunzmann, G., Remarks on the theory of suspension-body-type flowmeters (in German), *Automatisierung: Z. Messen, Steuern, Regeln* **4,** 3, 103–106, Mar. 1961.

6842. Cassetti, M., A method for the determination of the thrust in flight (in Italian), *Aerotecnica* **39,** 6, 308–315, Dec. 1959.

The proposed method consists of measuring flight velocity, height, variation of height with time and fuel consumption at two points, one in horizontal uniform flight, the other at equal height and velocity but in climbing or descending flight. Limitation and application of the method is discussed.

W. Wuest, Germany

6843. Becze, E. J., The flight measurement and analysis of tail loads due to pilot and aircraft response in symmetric manoeuvres, Nat. Res. Counc. Canada, Aero. Rep. LR-296, 30 pp. + figs., Jan. 1961.

6844. de Vries, G., The electrodynamic shaker as an instrument for precision measurement (in French), *Rech. Aéro.* no. 78, 47–55, Sept./Oct. 1960.

The coupled electro-mechanical system of an ideal electrodynamic shaker attached to a vibrating structure is analyzed. The coil impedance and the relation between the current in the coil and the force produced in a typical shaker are studied. Design considerations and use of the device in vibration measurement are discussed at the end. S.-F. Shen, USA

Thermodynamics

(See also Revs. 6754, 6755, 6760, 6767, 6828, 6955, 6970)

6845. Singh, K., Equation of state, *J. Sci. Indust. Res., India* 20 A, 4, 197–209, Apr. 1961.

Author gives a brief account of the basic principle of various statistical mechanical theories to determine the equation of state of a one-component gaseous system. It is a good résumé with adequate references but without new contributions or analysis of relative merit of different methods.

L. S. Dzung, Switzerland

6846. Lewis, R. M., Quantum statistics and the Boltzmann equation, AFOSR 746 (New York Univ., Inst. Math. Sci. Rep. HT-8), 58 pp., June 1961.

6847. Ho, L. T., Vanderslice, J. T., Fallon, R. J., Seigel, A. E., and Slawsky, Z. I., Pressure-density isentropes for argon at temperatures between 150 °C and – 140 °C and at pressures up to 1950 atm, *Physics of Fluids* **4,** 6, 784–787 (Letters to the Editor), June 1961.

6848. Viegas, J. R., and Peng, T. C., Electrical conductivity of ionized air in thermodynamic equilibrium, *ARS J.* **31,** 5, 654–657 (Tech. Notes), May 1961.

6849. Levy, S., Steam slip—theoretical prediction from momentum model, *ASME Trans.* **82** C (*J. Heat Transfer*), 2, 113–124, May 1960.

6850. McCarty, K. P., and Mason, E. A., Kirkendall effect in gaseous diffusion, *Physics of Fluids* **3,** 6, 908–922, Nov./Dec. 1960.

Paper deals with an effect in gas diffusion, analogous to the effect in solids. When two bottles containing different gases are joined by a capillary, there will be a net diffusive transfer since the lighter molecules travel faster than the heavier ones. The quickly resulting pressure difference tends to set up a bulk gas backflow, unless some provision for pressure equalization, such as a by-pass tube, is made. The speed of flow through such a by-pass was used by authors to measure the rate of diffusion.

Authors first describe the situation in terms of a simple phenomenological, and then a rigorous kinetic theory. Both treatments are excellent and detailed. In the experiment, involving seven pairs of gases (including the similar H_2–D_2 and the dissimilar H_2–CO_2 pairs), the diffusion rates were measured, and the kinetic theory was substantially verified. (The simple phenomenological theory was not.) Numerical values of auto and binary diffusion coefficients were deduced for some of the gases, and these checked against values indicated by the kinetic theory.

W. Hitschfeld, Canada

6851. Uhlhorn, U., Onsager's reciprocal relations for nonlinear systems (in English), *Ark. Fysik* **17,** 3/4, 361–368, 1960.

Using the time reversal invariance of the mechanical equations of motion and the methods of statistical mechanics, Onsager's reciprocal relations for linear irreversible thermodynamics are extended to include the case in which the phenomenological relations between fluxes and affinities are nonlinear. Since many rate processes (including many chemical reactions) are nonlinear, such extensions are significant steps in the development of a more general and more useful thermodynamics of irreversible processes. Applications of theoretical results to physical problems are not discussed.

E. L. Knuth, USA

6852. Baehr, H. D., Quasistatic changes of state and their relations to the reversible and irreversible processes in thermodynamics (in German), *Forsch. Geb. Ing.-Wes.* (*B*) **27,** 1, 3–9, 1961.

Article is an elementary but careful introduction to classical thermodynamics. Apart from a few special ideas, such as the author's distinction between process and change of state, the point of view is very much like that now common in the better treatises on the American Continent, thanks largely to the fundamental text by Zemansky. Author's treatment is purely phenomenological without statistical concepts. This is quite proper in a treatment of classical thermodynamics, but is a serious limitation in the discussion of irreversible processes. Considering the basic and didactic nature of the article, reviewer feels that many more examples of actual situations should have been included.

W. Hitschfeld, Canada

6853. Uhlhorn, U., On the foundations of the linear theory of irreversible processes: Part 1 and 2 (in English), *Ark. Fysik* **17,** 3/4, 257–314, 1960.

In part 1, the logical structure of the linear phenomenological theory of irreversible processes is discussed; in part 2, using a somewhat extended version of the Hilbert space theory of stationary stochastic processes, a probabilistic interpretation of the linear phenomenological theory and its relation to statistical mechanics is presented.

E. L. Knuth, USA

6854. Ljunggren, S., Comments on the theories of isothermal multi-component diffusion, Stockholm, Kungl. Tekn. Hogskol. Handl. no. 172, 30 pp. 1961.

Author discusses in detail relation between irreversible thermodynamic formulation (Onsager) and dynamical theory (Lamm) of multi-component diffusion, showing their equivalence. Transformation properties of diffusion equations and variables under component transformations are studied in tensor notation; invariance of the entropy production defines the tensorial character of the phenomenological coefficients.

I. M. Krieger, USA

6855. Skrotsky, G. V., and Shmatov, V. T., The thermodynamic theory of relaxation phenomena (in Russian), *Izv. Vyssh. Uchebn. Zavedeni: Fizika* no. 2, 138–143, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7169.

The thermodynamic theory of irreversible processes is applied to the examination of phenomena occurring in homogeneous systems in which an individual subsidiary system can be isolated, responsible for the manifestation of a specific physical property. If the interaction between the subsidiary systems is feebler than the interaction within a particular subsidiary system, two types of relaxation will be distinguishable: internal and external. Internal relaxation is characteristic for the process of approximation to an equilibrium state between the parameters of the isolated, subsidiary system. External relaxation is characteristic for the process of heat transfer from the isolated, subsidiary system to the remaining part—the thermostat.

For the evaluation of the state of the system in the presence of internal relation, the thermodynamic potential of the disequilibrium state is represented as the sum of the ordinary thermodynamic potential of the equilibrium state, and terms depending on the entropy in the disequilibrium state, of the particular subsidiary system.

By means of the method of thermodynamic analysis of irreversible processes it is possible to obtain an expression for the development of the entropy of a subsidiary system, which, for small deviations of the parameters from the equilibrium values, will describe the time-development of the state-change in the subsidiary system. By similar means an equation is obtained describing the development of the entropy in a system by heat-exchange between the subsidiary system and the thermostat allowing for the presence of external relaxation.

The derived equations are used to determine the rela a times. The solutions are used to define relaxation phenomena in ramagnetic substances obeying the Curie law, and to the problem of elastic relaxation.

T. V. Bazhenova
Courtesy Referativnyi Zhurnal, USSR

6856. Torocheshnikov, N. S., and Koval', Zh. A., An experimental investigation of the vortex effect in small-bore tubes (in Russian), *Nauchn. Dokl. Vyssh. Shkoly: Khimiya i Khim. Tekhn.* no. 3, 603–606, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7457.

The results are presented of experimental investigations on the determination of the design parameters of a vortex tube in which the gas flow separates into two components with different temperatures.

Tests have also been made with gas mixtures, indicating that the quantitative composition of the constituents of the mixture remains practically unchanged.

M. G. Dubinskii
Courtesy Referativnyi Zhurnal, USSR

6857. Demyanov, Yu. A., and Chereshneva, N. V., Method of determining the thermophysical characteristics of insulating material with recovery qualities due to a thermal impulse of a shock wave (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 153–154, Jan./Feb. 1961.

Heat and Mass Transfer

(See also Revs. 6470, 6733, 6779, 6780, 6851, 6853, 6854, 6890, 6909, 6916, 6920, 6955, 7012)

6858. Boyer, R. H., On some solutions of a nonlinear diffusion equation, *J. Math. Phys.* **40,** 1, 41–45, Apr. 1961.

A conventional partial differential equation of diffusion or thermal conduction can be written in terms of temperature, thermal conductivity (function of temperature), specific heat at constant volume (constant), time, and distance. Although solutions have already been published, author reports an independent derivation with elaborations and two apparently new applications, the first to transport of thermal energy in completely ionized gas by radiation rather than by mass movement of gas (earliest moments of expansion of nuclear bomb), and the second to an electrical transmission line with nonlinear series resistance and linear shunt capacitance. Paper is very brief and should be of interest to students of mathematical physics.

C. W. Smith, USA

6859. Kapinos, V. M., The solution of problems in stationary heat conductance by the method Apolli CF., taking into account the dependence of conductance coefficient on the temperature (in Russian), *Teploenergetika* **7,** 11, 74–78, Nov. 1960.

6860. Luke, Y. L., Numerical solution of the heat conduction equation, *Chem. Engng.* **68,** 1, 47–54, Jan. 1961.

Author discusses the use of a simple "marching" procedure to compute the transient temperature, heat flux and average temperature in a semi-infinite region having variable properties. In the reviewer's opinion the author should have mentioned other numerical techniques, such as the Crank-Nicholson method, which is generally more efficient than the one discussed.

E. H. Wissler, USA

6861. Bergles, A. E., and Kaye, J., Solutions to the heat-conduction equation with time-dependent boundary conditions, *J. Aerospace Sci.* **28,** 3, 251–252 (Readers' Forum), Mar. 1961.

This paper presents general solutions of a unidimensional heat flow in a solid body at constant material properties with time-dependent boundary conditions. The heat flux is expressed as a polynomial and the solution is determined by means of Laplace transformation. Numerical evaluation requires the use of design charts reported in a previous paper, *J. Aero. Sci.* **22,** 11, 755–762, Nov. 1955.

T. Ishimoto, USA

6862. Poddubny, G. V., An approximate solution of the problem of temperature waves in ground under the insulation of a cooler (in Russian), *Inzbener. Fiz. Zb.* **4,** 3, 83–91, Mar. 1961.

Paper is one in a series [Khaskind, *Izv. Akad. Nauk SSSR* no. 10, 1958, *PMM* no. 2, 1960 Poddubryi, Nauch. Zap Kremenets. pedinst. v.5, 1960; Nauch. Zap. Odess. Pedinst. v. 23, 1959] containing studies of the penetration of thermal waves from a slab into a half-space. The present paper contains an approximate solution, with useful auxiliary tables, for a slab of width $2l$ and thickness $\delta (\delta \ll l)$ which remains in contact with a half-space. The exact solution which has been obtained previously in terms of Mathieu functions is simplified by the application of the Fock-Hartley method and written in terms of an exponential and a periodic Mathieu function. Auxiliary tables are given to facilitate numerical solutions.

J. Kestin, USA

6863. Mirzoyeva, L. M., The derivation of the generalized heat-exchange relationship for a biphasal system (gas-solid substance) (in Azerb.), *AzerbSSR Elmler Akad. Kheberleri: Fiz.-Tekhn. ve Kimia Elmleri Ser.* no. 3, 53–64, 1958; *Ref. Zb. Mekh.* no. 7, 1959, Rev. 7777.

A family of equations is analyzed, determining the behavior of a biphasal system moving along a cylindrical pipe in conditions of heat exchange between the moving (flowing) medium and the pipe wall. It is for this purpose assumed that, in view of the high concentration of solid particles and their small diameter, the temperature of the particles and of their surrounding, elementary gas masses will be identical.

It is demonstrated that, in the conditions obtaining, the experimental values obtained for the heat exchange and resistance should be presented in the form of the relationships

$$N = \psi_1 \left(\varphi_0,\ R,\ P,\ \frac{d}{l},\ \frac{\lambda_0}{\lambda},\ \frac{\rho_0 d_0}{\rho d} \right)$$

$$E = \psi_2 \left(\varphi_0,\ R,\ P,\ \frac{d}{l},\ \frac{\rho_r\, dr}{\rho d} \right)$$

In the above, N, E, R, P are, correspondingly, the Nusselt, Euler, Reynolds and Prandtl (for the gaseous phase) numbers; φ_0 = volume of the solid phase in 1 m³ of the mixture in the starting cross section of the pipe; d/l = ratio of the pipe diameter to its "flow" length; π_0/π = ratio of the coefficient of heat conductivity of the particles of the solid phase to the coefficient of heat conductivity of the gas; $\rho_0 d_0/\rho d$ = ratio of the product of the particle density by the particle diameter to the product of the gas density by the pipe diameter.

The last two criteria define the specific nature of the processes of heat exchange in the conditions under consideration.

G. A. Varshavskii
Courtesy Referativnyi Zhurnal, USSR

6864. Kubanskii, P. N., Theory of acoustic streaming of heated solids, *Soviet Phys.-Acoustics* **6,** 4, 462–467, Apr./June 1961. (Translation of *Akust. Zh., USSR* **6,** 4, 462–467, Oct./Dec. 1960 by Amer. Inst. Phys., New York, N. Y.)

Author develops expansion of acoustic and convective fields to compute heat-transfer coefficients from heated solid bodies in presence of an intense sound wave. For moderate sound intensities, a superposition of acoustic and convective streaming is shown to hold, enabling one to use previous solutions of both to compute desired coefficients.

Method and results are conceptually appealing but no indication as to amplitude limits are given. No numerical results are presented.

R. Lyon, USA

6865. Tellep, D. M., Heat transfer in low Prandtl number flows with variable thermal properties, *ARS J.* **31,** 5, 652–654 (Tech. Notes), May 1961.

Author starts with the mass, momentum and energy balances for low-speed two-dimensional flow. Applying various transformations, and the boundary conditions of constant wall and free-stream temperatures, a family of solutions is obtained without trial and error, based on power-law variation of thermal conductivity, density and specific heat with temperature.

The equations for local wall heat flux and Nusselt number are provided. Using free-stream properties introduces little error, however.

C. F. Bonilla, USA

6866. Krinkova, M. G., Some problems of the heat exchange between a gas and solid particles (in Russian), *Inzbener.-Fiz. Zb.* **1,** 4, 10–16, 1958; *Ref. Zb. Mekh.* no. 7, 1959, Rev. 7778.

The results are presented of experimental investigations on the heat exchange of small, metal balls (20–50-mm diameter), at values of the Reynolds number between 200 and 1.1×10^5, and cubes of 20 mm and 30 mm length of side. The coefficients of heat emis-

sion (heat loss) were determined in unsteady conditions, during cooling of the walled balls.

The experiments were evaluated with the following ratios of the Nusselt number for the balls:

$$N = AR^n$$

$A = 8.2$, $n = 0.160$, for $2 \times 10^2 \leqslant R \leqslant 1 \times 10^3$
$A = 1.06$, $n = 0.457$ for $1 \times 10^3 \leqslant R \leqslant 1.2 \times 10^4$
$A = 0.27$, $n = 0.600$ for $1.2 \times 10^4 \leqslant R \leqslant 1.1 \times 10^5$

The heat transfer from the cubes at $R \leqslant 9 \times 10^3$ was practically the same as from the balls; at $R \geqslant 9 \times 10^3$ it was somewhat higher. The relative surface roughness of the balls, equalling $k = 0.016$, at $R < 3 \times 10^4$, did not influence the intensity of heat transfer, at $R > 3 \times 10^4$ roughness increased the rate of heat exchange.

The influence of rotation on the intensity of the heat exchange was studied on a ball of 20-mm diameter. It was found that at a maximum peripheral velocity below 0.519 m/sec, rotation did not increase the intensity of heat exchange; at higher values of the peripheral velocity, the heat exchange is somewhat greater. This increase augments with decreasing value of the Reynolds number.

At values of $R < 1500$ (depending on the speed of rotation), the rate of heat exchange is independent of the value of R, and is determined by the rotational velocity.

G. A. Varshavskii
Courtesy Referativnyi Zhurnal, USSR

6867. Lemlich, R., A musical heat exchanger, *ASME Trans.* **83** C (*J. Heat Transfer*), 3, 385–386 (Tech. Briefs), Aug. 1961.

Writer reports the results of some simple experiments in which he investigated the effect on forced convective heat transfer produced by a vibrating musical reed.

From author's summary

6868. Eckert, E. R. G., and Carlson, W. O., Natural convection in an air layer enclosed between two vertical plates with different temperatures, *Inter. J. Heat Mass Transfer* **2**, 1/2, 106–120, Mar. 1961.

Temperature fields were measured using a Zehnder-Mach interferometer. Local heat-transfer coefficients were computed from the temperature gradients normal to the plates. Two flow regimes, depending on the Grashof number and the height-to-thickness ratio, were detected. In one, heat is transferred by conduction in the central part of the layer with convection contributing only in the corner regions. In the other, boundary layers exist on the plates and the temperature is uniform in the central core. Relations for local and average heat-transfer coefficients are presented.

E. H. Wissler, USA

6869. Braun, W. H., Ostrach, S., and Heighway, J. E., Free convection similarity flows about two-dimensional and axisymmetric bodies with closed lower ends, *Inter. J. Heat Mass Transfer* **2**, 1/2, 121–135, Mar. 1961.

Authors consider the problem of free convective flow about a two-dimensional or axisymmetric body, and look for body shapes which lead to "similar" solutions of a rather general nature. Solutions of the resulting ordinary differential equations are derived by an approximate method for a number of possible bodies, boundary-layer thicknesses, pressure and heat transfer being thus calculated. Possible generalizations are discussed.

N. Curle, England

6870. Gamayunov, N. I., An investigation into heat and moisture transfer in a finite bar (in Russian), *Inzhener.-Fiz. Zh.* **3**, 4, 11–17, Apr. 1960.

Paper gives solution of differential equations of heat and mass transfer in a finite one-dimensional bar. Experiments are briefly described which were carried out with moist peat, using radioactive tracer elements, and observed moisture distribution was compared with analytical predictions.

Y. R. Mayhew, England

6871. Tsoy, P. V., The problem of heat and moisture transfer for a three-dimensional semi-infinite medium with boundary conditions of the second type (in Russian), *Inzhener.-Fiz. Zh.* **3**, 6, 112–119, June 1960.

Paper cannot be fully understood without (1) a nomenclature, as symbols are not explained, and (2) using other papers to which reference is made.

Y. R. Mayhew, England

6872. Taylor, J., Beating the heat barrier, Aero. Res. Counc. Lond. Curr. Pap. 545, 13 pp. + figures, 1961.

A short survey is made of the characteristics of aerodynamic heating at supersonic speeds and of the properties of a typical aluminum alloy when exposed to increased temperatures for prolonged periods. With this information, an estimate is made of the minimum combined weight of cooling and insulation required for an aluminum aircraft structure; the study extends to $M = 10$, height of 250,000 ft and a range of 5000 miles.

From author's summary

6873. Tirskii, G. A., Surface melting of a semi-infinite body in plane and axially symmetric incompressible gas flow, *Soviet Phys.-Doklady* **5**, 3, 501–504, Nov./Dec. 1960. (Translation of *Doklady Akad. Nauk SSSR (N.S.)* **132**, 4, 785–788, June 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

Author sets forth governing equations for title problem with constant transport properties in the air phase. No attempt is made at solving the resultant boundary-value problems, and no reference is made to the work of Roberts [AMR **14**(1961), Rev. 1609] who solved the same problem with temperature-dependent transport properties, and who included numerical examples.

T. R. Goodman, USA

6874. Vatazhin, A. B., Ablation of a plate placed in a supersonic or high-temperature gas flow (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 7–13, Nov./Dec. 1959.

This is an exceptionally interesting and valuable paper with a typical Soviet approach: clear formulation of the problem; strict general theory; numerical appreciation of the simplifications allowed; and, finally, technological solutions. Everybody working on problems of ablation and sublimation generally—and on re-entry problems, particularly—will welcome this article.

G. A. Tokaty, England

6875. Beckwith, I. E., and Cohen, N. B., Application of similar solutions to calculation of laminar heat transfer on bodies with yaw and large pressure gradient in high-speed flow, NASA TN D-625, 95 pp., Jan. 1961.

Integral method for calculation of heat-transfer distributions on bodies of revolution or yawed cylinders in high-speed flows is developed for laminar boundary layers.

Method involves quadrature of function of the pressure distribution and satisfies the integral energy equation with the assumption of local similarity, wherein actual boundary layer profiles are replaced by corresponding profiles from a family of similar solutions.

Comparisons are made with works of Kemp, Rose and Detra [*J. Aero/Space Sci.* **26**, 7, 421–430, July 1959], Lees [*Jet Propulsion* **26**, 4, 259–269, Apr. 1956; AMR **9**(1956), Rev. 3390], [*J. Aero. Sci.* **23**, 10, 901–912, Oct. 1956] and Sline and Wanlass [NACA TN 3344, 1954; AMR 8(1955), Rev. 2527].

R. A. A. Bryant, Australia

6876. Pomerantsev, A. A., Wall heating by a supersonic gas flow, *Inter. J. Heat Mass Transfer* **2,** 1/2, 8–14, Mar. 1961.

Paper concerns temperature distribution along a wall, in particular of wedge shape, heated by supersonic flow of a gas. Wall temperature is assumed to vary as $T_w = T_0 + A(t)x + B(t)x^2$, where t is time and T_0 is the known temperature at the nose of the wall, and assumed to approach that of the disturbed side of the shock wave. It is assumed that $\partial T_w/\partial x = 0$ at $x = L$. Equation of heat conduction along wall is averaged over the wall thickness to give differential equation for $B(t)$. Normal temperature gradient $\partial T/\partial y$ appearing here is obtained through application and modification of equations and results of Chapman and Rubesin for flow over a flat plate. After averaging heat conduction equation also over length L of wall, equation is solved for $B(t)$. Comparison of theoretical results is made with observations of the flight of a V-2 rocket by Fischer and Norris.

Right side of Eq. [3′] and of equation at bottom left of p. 10 should read: "$(\Delta\ \partial T/\partial y')_{y'=0}$." M. Morduchow, USA

6877. Leontiyev, A. I., A thermodynamic analysis of the gas flow in a cylindrical pipe in the presence of heat and mass exchange (in Russian), *Nauchn. Tr. Mosk. Lesotekhn. In-ta* no. 9, 213–219, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7765.

A method of thermodynamic analysis is proposed for calculating the distribution of the parameters of a linear gas flow along a cylindrical duct in the presence of evaporation from the walls,—i.e., in the presence of heat- and mass-exchange. The wall temperature is assumed to be constant; the method of calculating the parameters of the gas flow, averaged over the length of the duct, is described on the assumption of particular, given conditions at the entry; the usual starting system of equations of gas dynamics is employed. Making some material assumptions (the author makes use of the fact that certain thermodynamic parameters of a paragaseous flow are temperature- and humidity-independent), it is found possible to present a solution of the problem in complete form. Relationships are derived, characterising the linkages between the parameters. The sequence of their application to practical calculations is explained.

It is maintained that a similar, although more complicated, solution can be obtained with inclusion of the influence of frictional forces on the gas flow. G. E. Khudgakov

Courtesy Referativnyi Zhurnal, USSR

6878. Kosterin, S. I., Semenov, N. I., and Tochigin, A. A., Relative velocities of a steam-water flow in vertical unheated pipes (in Russian), *Teploenergetika* **8,** 1, 58–65, Jan. 1961.

Experiments were performed with steam-water mixtures flowing through vertical, unheated pipes (7.5 m long, 17 and 30 mm in diameter). The effect of the Froude number (range 14 to 366) was investigated at three pressure levels (40, 70 and 120 atm). The volumetric vapor fraction α was determined by weighing the test section and by measuring the attenuation of gamma rays through the mixture.

Experiments show that α is a function of the system pressure, of the Froude number and of the volumetric flow concentration β, defined as the ratio of the volumetric flow rate of the vapor divided by the sum of the volumetric flow rates of the liquid and of the vapor. At a given pressure and in the range $0 < \beta < 0.7$, the vapor fraction α is linearly related to β, i.e., $\alpha = C\beta$ where the constant C is smaller than unity and is a weak function of the Froude number. As the pressure or the Froude number increases the value of C approaches unity. N. Zuber, USA

6879. Kallander, J. W., and Weller, J. F., Radiation behavior of electrical materials and components for space vehicles, Rep. NRL Prog., 11-17, May 1961.

Solar cells, ordinary quartz shields, and adhesives for cementing solar cells to satellite skins have been exposed in the laboratory to the kinds of high-energy radiation that would be encountered in space vehicles. The data presented here pertain to electron irradiation and its effect on the electrical characteristics of solar cells and their associated materials. It was found that the initial output of a solar cell is influenced greatly by the thickness of the shield, that the load characteristics are affected by the darkening of the shield, and that the maximum efficiency decreases as the cell is exposed to larger and larger doses of electron irradiation. Results of studies of epoxy adhesives so far are similar for different samples having the same cure, but vary with the cure—the slower the cure, the more radiation resistant is the adhesive. From authors' summary

6880. Funk, J. P., A numerical method for the computation of the radiative flux divergence near the ground, *J. Meteorol.* **18,** 3, 388–392, June 1961.

Author describes a method of computing divergence of radiative flux due to water vapor in the atmosphere. Although applicable to atmosphere of any thickness, he finds method most suitable to the layer near the ground. It can be used in place of method given by D. L. Brooks [*J. Meteorol.* **7,** 313–321, 1950; AMR **4**(1951), Rev. 2305] over which author claims superiority for thin layers. For use one needs tables of emissivity versus path length equivalent to those of E. L. Deacon [*Austral. J. Sci. Res.*, (*A*) **3,** 274–383, 1950; AMR **4**(1951), Rev. 2773]. F. I. Badgley, USA

6881. Bolin, J., Tenukest, C. J., and Milner, C. J., Plastic-replica mirror segments for a solar furnace, *Solar Energy* **5,** 3, 99–102, July/Sept. 1961.

6882. Lueder, H., Radiant conditioning of enclosed rooms, *Sulzer Tech. Rev.* **41,** 3, 33–46, 1959.

This work deals with the technical problem of the exchange of radiation in a room with at least partially reflective bounding surfaces and is an initial contribution to the development of radiant conditioning methods of enclosed rooms. Methods of calculating radiation exchanges, including reflection, in an enclosed space are particularly important for the problem. In this paper (in which the heat flows are represented as functions of radiation factors) a method is first explained with the aid of a particularly straightforward example and is then elaborated, calculating the effect on occupants of the room and with allowances for radiation entering and escaping through the window. Author demonstrates that comfortable conditions for the human body, in respect to radiation, can be achieved most effectively by measures which also make for maximum economy of heat.

The self-regulation of the temperatures in the enclosed room can also be made amenable to calculation by the method used in this work. A. Pignedoli, Italy

6883. Koh, J. C. Y., Sparrow, E. M., and Hartnett, J. P., The two phase boundary layer in laminar film condensation, *Inter. J. Heat Mass Transfer* **2,** 1/2, 69–82, Mar. 1961.

Laminar-film condensation on a vertical plate was first treated by Nusselt in 1916. In this study the effects of inertia, of heat convection, and of the surface shear at the vapor interface were neglected. Nevertheless, the results of this study have proven to describe the physical phenomenon to a high degree of accuracy. In recent years the problem has been treated effectively by applying the methods of boundary-layer analysis. Very elegant solutions have been obtained and the neglected effects have been taken into account in a series of successive papers. In the present paper the effect of the shear force at the liquid-vapor interface has been considered in addition to the acceleration and convection terms.

It is concluded that the effect is negligible for liquids of high Prandtl numbers and usually insignificant even for Prandtl numbers near unity. Depending on the exact conditions, the theoretical results show a reduction of the order of 25% in the Nusselt number for liquids of very low Prandtl number such as liquid metal. The effect seems to be caused principally through a modification of the velocity profile which is sensitive to the outer boundary condition at the relatively low viscosities which correspond to low Prandtl numbers. R. H. Sabersky, USA

6884. Dedert, W. G., Evaporation, *Indust. Engng. Chem.* **53,** 8, 669–673, Aug. 1961.

6885. Browning, S. C., and Sebastian, J. J. S., Ceramic heat exchangers for high-temperature heat transfer from helium, *Indust. Engng. Chem.* **53,** 3, 191–196, Mar. 1961.

Bench test is made of a single tube 30 in. long, 1-1/2 in. i.d. vitreous alumina heat exchanger. Helium at temperature 1450 F to 2665 F flowed at low velocities and about atmospheric pressure inside tube cooled by air on outside. Velocities were too low to produce turbulent flow. Authors correlated results by

$$Nu = 1.10\,(4/\pi\,Gz)^{0.86}\,(T_a/T_w)^{-0.9}, \text{ for } T_a/T_w \text{ less than 3.}$$

To the reviewer these temperature values appear to be in Fahrenheit rather than absolute degrees, so equation can apply only at high temperatures. At values of

$$Gz > 3, Nu \text{ is value at } Gz = 3.$$

Authors had difficulty with seals for ceramic high-temperature construction. Other problems were thermal shock and stresses. Work reported is but first step in program to apply nuclear energy to meet high-temperature endothermic reaction requirements. To meet broad objective, reviewer considers that program must be more varied. The tests were too limited to be considered as demonstration that the apparently favorable properties of helium will lead to commercial utilization. D. Aronson, USA

6886. Grobman, J., A technique for cryopumping hydrogen, NASA TN D–863, 28 pp., June 1961.

Experimental tests performed in vacuo indicated that a chemical adsorption reaction can be used to facilitate the cryopumping of hydrogen with liquid-nitrogen-cooled condensers. Cryopumping is accomplished by reacting hydrogen with oxygen to form water, which will readily condense on a liquid-nitrogen-cooled surface. The reaction in vacuo was performed on a solid catalyst, which consisted of a bed of palladium-coated alumina pellets. Cryopumping was observed at pressures as low as about 0.4 micron of mercury. A laboratory cryopump consisting of 5.8 pounds of catalyst and a liquid-nitrogen-cooled condenser achieved a pumping speed of about 570 liters per second at 1.0 micron of mercury.

A laboratory model of a cryopump which could be used in an electric rocket test facility was studied. The experimental data thus obtained were used to estimate the size of the catalyst bed necessary to test a 50-kilowatt electric thermal rocket with a hydrogen propellant flow rate of 6.3×10^{-4} kilogram per second (a pumping speed of 580,000 liters/sec at an operating pressure of 10 microns of mercury). From author's summary

Book—6887. Styrikovich, M. A., Kholodovskii, G. E., and Fomichev, M. S., edited by, Heat engineering and hydrodynamics, AEC Tr. 4206. (Translated from Vol. 4, Proc. All-Union Scientific-Technical Conference on the Use of Radioactive and Stable Isotopes and Radiation in the Peoples' Economy and in Science, Moscow, Apr. 4–12, 1957), Washington, D. C., OTS, Dept. of Commerce, Sept. 1960, 94 pp. $2.25. (Paperbound)

Combustion

(See also Revs. 6718, 6959, 6960)

6888. Brunold, Miss M. P., Delbourgo, R., and Laffitte, P., On the inflammability ranges of formaldehyde and carburetted air under reduced pressure, *Combustion and Flame* **5,** 2, 191–194, June 1961.

The inflammability regions of formaldehyde and air with small amounts of hydrocarbon (2.4 to 5.4 per cent) have been studied. The addition of propane or methane leads to a strong inhibition of the formaldehyde range together with the appearance of a second lobe structure of the curves described with pseudo cool flame characteristics. The influence is continuous and leads to a well laid out family of curves. Whenever hydrocarbon is present in the mixture, even in trace amounts, the properties of flames encountered are those of the hydrocarbon and not those of the formaldehyde mixture.

From authors' summary by A. Levy, USA

6889. Gregory, J. W., and Straight, D. M., Ignition of hydrogen-oxygen rocket combustor with chlorine trifluoride and triethylaluminum, NASA TN D–684, 24 pp., Apr. 1961.

6890. Lovachev, L. A., The theory of flame propagation in branched and unbranched chain systems, *Combustion and Flame* **4,** 4, 357–367, Dec. 1960.

An analysis is presented of flame propagation for the case that the chemical reaction in the flame is an unbranched chain reaction. By making certain approximations, author is able to give analytic expressions for the burning velocity in terms of the transport properties and chemical reaction rates. Burning velocities for H_2–Cl_2 flames calculated from the approximate formulas are in good agreement with values from an exact numerical solution and from experimental measurements. The formulas are also used to obtain rate constants in the hydrogen-oxygen flame from burning velocity data. Reviewer believes this work to be a useful addition to basic understanding of flame propagation.

A. E. Potter, Jr., USA

6891. Herbert, M. V., The effect of fuel distribution on reaction rates, *Aero. Quart.* **12,** 1, 41–50, Feb. 1961.

Method of analysis of theoretical reaction rate with nonuniform fuel distribution is presented. For case of point-source invector in a parallel pipe, reaction rate is calculated for a number of cases. Compared with overall stoichiometric mixture, loss due to uneven distribution is found to be 75% for worst case considered, with no significant change of shape of stability loop. Author emphasizes tentative nature of analysis.

D. G. Shepherd, USA

6892. Van Tiggelen, A., New developments of a kinetical study of flames, AFOSR TN 60–1210 (Univ. Louvain, Belgium, Lab. for Inorganic Chem. TN 3), 64 pp., Feb. 1961.

6893. Kowalewicz, A., Stability problem of the flow with combustion in variable area duct, *ARS J.* **31,** 4, 558–560 (Tech. Notes), Apr. 1961.

A one-dimensional, time-varying model is postulated which is described by four equations: conservation of mass, momentum, chemical species, and isentropic relation between density and pressure. Introduction of a stream function reduces the system to a single equation which has the same form as the telegraph equation if the nonlinear terms are considered as "sources." Although the equation is not solved, the known behavior of the telegraph equation can be used as a guide. The criteria for stability are the same as Rosen [G. Rosen, "Nonlinear pressure oscillations in a combustion field," *ARS J.* **30,** 422-423, 1960; AMR **13**(1960), Rev.

6004] found by a similar analysis. In addition, the influence of duct area changes on stability are stated.

Author implies that the analysis is valid for heterogeneous or homogeneous combustion; however, reviewer feels that the equations used in the derivation restrict the results to a model of droplets-to-burned-gas. The author states that Rosen's order of magnitude analysis of the damping term does not seem to be justified. It is the algebraic sign of the damping term (plus sign gives damped transients and a negative sign, exponential growth) that is important. Rosen's interpretation of the term appears to the reviewer to be correct.

The paper represents an interesting new approach to the problem of combustion oscillations which plague propulsion engineers.

A. Fuhs, USA

6894. Schalla, Rose L., Examination of pressure oscillations induced by changes in the burning rate of flames, NASA TN D-764, 14 pp., Apr. 1961.

An extension of the author's previous work [*Combustion and Flame* **5,** 1, 45–53, Mar. 1961] leading to generalization that a source of pressure oscillations is present in any system where a flame experiences an increase in heat release rate. Results show that for flame propagation across a composition gradient, the amplitude of oscillations is reduced by decreasing the ratio of tube volume to exit area. The oscillation frequency, however, increases as the amplitude decreases. Another method of increasing the heat release rate is by flame propagation through a tube with abruptly changing cross-sectional area, yielding similar results to those obtained by passage across a composition gradient.

Reviewer considers that, while it is satisfactory that such a generally accepted theory should be confirmed, the work offers no new line of approach to the study of combustion instability in rocket motors, afterburners, etc.

J. K. Kilham, England

6895. Guenoche, H., and Langlois, J., Acoustical vibration of pipes connected to a cylindrical combustion chamber (in French), *Rev. Inst. Fr. Petrole et Ann. Comb. Liquid* **15,** 5, 906–921, May 1960.

Longitudinal vibrations in combustion chambers consisting of a wide section of length l_1 and a narrow (nozzle) section of length l_2 were studied. For $l_2 > l_1$, fundamental frequency was practically independent of length of burner attached. For $l_2 > 3l_1$, influence of the wide section was negligible. Agreement between calculated and observed frequencies is rather good. Little difference was found in the behavior of premixed or diffusion flames.

V. Salmon, USA

6896. Manson, N., Determination of the characteristics of detonation waves by the "inverse method" (in French), *Publ. Scient. Tech. Min. Air, France* no. 366, 46 pp., 1960.

Two relations of aerothermochemistry are applied to classical Chapman-Jouguet detonation waves which then permit relatively simple numerical solutions of wave speed and the state of the gaseous products (except for temperature). The results are not new but the method will be of use to those who wish to reduce the large amount of numerical effort required for each wave solution. Examples are given for $H_2 + O_2$ and $C_2H_2 + O_2$ gaseous detonations and a detonation in nitromethane.

R. A. Gross, USA

6897. Ershin, Sh. A., The analysis of a diffusion flame in gas (starting length of the flame) (in Russian), *Trudf In-ta Energ. Akad. Nauk KazSSR* **1,** 88–100, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7826.

A method is described for the approximate calculation of the starting length of a turbulent gas jet, propagating in a stationary medium, in the presence of diffusional combustion. The method is founded on the assumption of conservation of similarity of the fields of impulse flow, heat content and water, in the burning jet, which is, in fact, a generalization of the hypothesis stated by L. A. Valis [*Izv. Akad. Nauk KazSSR, Ser. Energet.* no. 10, 87–102, 1958] for the case of a free-turbulent gas jet. It is assumed that the flame front of infinitely small thickness becomes established on a surface in which, in the presence of isothermal mixing, the concentrations of the fuel and the oxidant are stoichiometrically related.

The results of the analysis explain the influence of the degree of heating of the gases in the combustion zone on the geometric characteristics of the boundary layer of the jet, and disclose a relationship between the location of the flame front in the jet and the calorific value of the burning gas and its starting temperature, as well as Prandtl's turbulence number.

The method developed is illustrated on an exemplary calculation of the combustion of a vaporized gasoline jet in air.

The author has made experiments to verify the fundamental conclusions from his analysis [*Izv. Akad. Nauk KazSSR, Ser. Energet.* no. 11, 1956] but does not correlate these with the results presented in this paper.

O. V. Yakovlevskii

Courtesy Referativnyi Zhurnal, USSR

6898. Boenecke, H., Application of flow research to industrial furnaces with particular emphasis on soaking pits, *J. Iron Steel Inst. Lond.* **197,** 4, 283–295, Apr. 1961.

6899. Stewart, D. G., Combustion in ram jet engines, *Instn. Engrs. Austral. EM* 3 (*Elect. Mech. Engng. Trans.*), 1, 43–51, May 1961.

Paper reviews requirements of ramjet combustion chambers, current research and development practice, typical designs, typical performance. Future trends and problems are outlined.

H. R. Hazard, USA

Prime Movers and Propulsion Devices

(See also Revs. 6503, 6743, 6769, 6786, 6810, 6811, 6812, 6813, 6814, 6815, 6816, 6817, 6827, 6828, 6842, 6893, 6899, 6958, 6959, 6960)

6900. Benson, R. S., and Woods, W. A., The energy content of exhaust pulses in the exhaust system of a supercharged two-stroke-engine model, *Inter. J. Mech. Sci.* **2,** 4, 231–250, Apr. 1961.

Energy content of exhaust pulse is defined as maximum work that could be performed by exhaust gas in an ideal gas turbine. Continuous mean power is defined as average value of maximum instantaneous power that can be developed by turbine driven by pulse exhaust. Theoretical analysis deals with influence of wave action on these quantities in the exhaust of a turbo-charged two-stroke-cycle engine, and shows that power available in exhaust pulses increases with increasing engine speed and release pressure and with decreasing nozzle size and pipe length and bore. It also shows, however, that there is an optimum size below which power available decreases.

Experimental results are in good qualitative agreement with the theoretical predictions.

J. V. Foa, USA

6901. Hesselbrock, H., Blade damage on steam turbines (in German), *Brennstoff-Wärme-Kraft* **13,** 1, 8–12, Jan. 1961.

Blade damage often is caused by disregard of elementary laws of flow. Traces left by the steam in the boundary layer of stationary and moving blades make it possible to recognize faulty steam flow. Steps sometimes taken for the removal of water from

the end stages of condensing turbines have caused blade damage in some cases. Unsuitable design may lead to disturbing impulses of various frequencies which create the probability of a resonance with an individual critical vibration of the blades.

From author's summary

6902. Ahlberg, J. H., Hamilton, S., Migdal, D., and Nilson, E. N., Truncated perfect nozzles in optimum nozzle design, *ARS J.* **31,** 5, 614–620, May 1961.

Paper brings together a great deal of practically useful information on design of propulsive nozzles. A simple technique leads to a simple method for closely approximating such optima as minimum length or minimum surface area. The paper additionally covers: (i) calculation and effect of wall friction; (ii) effect of fuel properties; (iii) verification of theoretical results with measured wall pressures; (iv) separation data for excessively high back pressures.

A. H. Shapiro, USA

6903. Kalmykov, I. I., The calculation of a gas ejector (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Aviats. Tekhn.* no. 2, 93–103, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7488.

The results are presented of experimental investigations on gas ejectors with a cylindrical mixing chamber and a central, high-pressure gas jet. The experimental results are compared with analytical data obtained by the method of M. D. Millionshchikov and G. M. Riabinkov. It has been found that these results agree satisfactorily at relatively small pressure gradients of the order of $p_o < 5$. At larger gradients, the deviation between the analytical and the experimental results may amount to 50%. It is demonstrated that, at the diffuser entry, the flow is pronouncedly inhomogeneous. The velocity profile approaches a parabolic form with a central, supersonic nucleus, occupying up to 1/3 of the area of the mixing chamber. The mean velocity of the flow at the exit from the mixing chamber is, however, subcritical.

From the experimental results, a more accurate relationship is developed for the critical value of the coefficient of ejection.

It is shown that the conditions for maximum ejector performance and maximum economy are widely divergent, particularly at low values of the ejector compression factor. A method is presented for calculating a gas ejector with a cylindrical mixing chamber, working under maximum economy conditions.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR

6904. Namoradze, A. G., An experimental universal ejector (in Georgian), Sakartvelos Politeknikuri Instituti. Shromebi no. 3 (60), 86–92, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7489.

A design is suggested for a pulsating ejector working on diesel engine exhaust gases. The suggested form of construction enables the assembly and testing of single- and multiple-nozzle layouts with varying geometrical proportions of the flow length of the ejector. The construction of the different elements is described in detail. This ejector further enables the experimental development of various ejector elements.

The efficiency of the suggested ejector has been experimentally tested, directly on a full-scale D-54 engine.

The author is of the opinion that the described experimental universal ejector is suitable for rapid and inexpensive qualitative investigation of the optimum dimensions and parameters of gas-air, pulsating ejector.

Yu. A. Lashkov

Courtesy Referativnyi Zhurnal, USSR

6905. Stenning, A. H., Rapid approximate method for analyzing nuclear rocket performance, *ARS J.* **30,** 2, 169–172, Feb. 1960.

6906. Forrester, A. T., and Teem, J. M., Advances in electrostatic propulsion, *Astronautics* **6,** 1, 34–37, Jan. 1961.

6907. Saunders, N. T., Experimental method of producing porous tungsten for ion rocket engines, NASA TN D-864, 23 pp., June 1961.

The effects of particle size and sintering temperature on the permeability of tungsten ionizers have been investigated in a preliminary program. Tungsten powders of 1, 10, and 20 microns average particle size were sintered at temperatures in the range of 2250° to 2900°F. Results from density measurements, metallographic examination, and nitrogen flow tests on disks representing the various combinations of particle size and sintering temperature have shown that porosity varies inversely with sintering temperature for 1-micron particles but that sintering temperatures up to 2900°F had no effect on the porosity of samples produced from 10- and 20- micron particles.

Finally, a method of producing thin porous platelets has been developed. This method utilizes the sintering of compacted 1-micron powder at 2750°F for 20 hours in a hydrogen atmosphere. Platelets manufactured by this method have been successfully operated in an experimental ion engine.

From author's summary

Magneto-fluid-dynamics

6908. Wooler, P. T., Instability of flow between parallel planes with a coplanar magnetic field, *Physics of Fluids* **4,** 1, 24–27, Jan. 1961.

In 1933 Squire proved that for incompressible flow the minimum critical Reynolds number corresponds to a disturbance propagating in the flow direction. Subsequently for each new problem in the field of hydrodynamic stability the investigator has sought a simplification to a similar form. Unfortunately this simplification does not generally exist. It might be expected that generalizations of Squire's theorem to magnetohydrodynamics stability problems are rare. Professor Wooler has shown that in the case of a Couette flow with an oblique magnetic field, Squire's theorem is not generally valid. Further he concludes that "... The minimum critical Reynolds number for an oblique magnetic field is finite however large the field, whereas when field and flow are parallel the flow may be completely stabilized...."

Drazin has shown that in the case of a jet [*J. Fluid Mech.* **8,** 1, 130–142, 1960; AMR **14**(1961), Rev. 1054] the parallel magnetic field can be destabilizing. It would be interesting if Professor Wooler would extend his results to the stability of jets in oblique fields.

E. E. Covert, USA

6909. Gupta, A. S., On the laminar flow of an electrically conducting fluid under pressure gradient in channels with porous walls in the presence of a transverse magnetic field, *J. Sci. Engng. Res.* **4,** 2, 401–407, July 1960.

Theoretical. The exact, time-independent, hydromagnetic Stokes-Navier equation is solved, whereby the velocity distribution is found to depend on four nondimensional parameters, viz. the magnetic pressure number, suction Reynolds number and two others related to viscous and magnetic drag. The drag coefficient depends strongly on the magnetic field strength. The solution of the heat-transfer problem, including viscous and Joule dissipation, is shown to depend on the above-mentioned parameters (except Reynolds number) as well as on the Peclet number.

P. Savic, Canada

6910. Regirer, S. A., On the flow of an electrically conducting fluid in tubes of arbitrary cross-section in the presence of a mag-

netic field, *Appl. Math. Mech. (Prikl. Mat. Mekh.)* **24,** 3, 790–793, 1960. (Pergamon Press, 122 E. 55th St., New York 22, N.Y.)

6911. Rusanov, V. D., et al., Investigation of magnetoacoustic resonance in a plasma with aid of double electric probes, *Soviet Phys.-JETP* **12,** 6, 1041–1044, June 1961. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **39,** 6 (12), 1497–1502, Dec. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

The concentration of a plasma in a magnetoacoustic wave is measured. It is shown that the ionization increases considerably and rapidly in magnetoacoustic resonance. The radial concentration distribution in the plasma is almost uniform.

From authors' summary

6912. Hershberger, W. D., Radiation field and *Q* of a resonant cylindrical plasma column, *Physics of Fluids* **4,** 6, 740–742, June 1961.

A cylindrical column of plasma will resonate when placed in an electromagnetic field where ***E*** and the direction of propagation are perpendicular to the column. Author assumes a particular variation for electron motion, associated with the transverse dipolar mode, finds the field configuration about the column and calculates the selectivity factor *Q* for the case where the plasma diameter is less than the incident wavelength. Radiation losses for this mode are relatively large for columns of moderate optical thickness. For slender columns the plasma is a poor radiator. Some experimental verification of this model is offered, although radiation losses in the laboratory are in general higher than predicted by the theory. This is attributed to other dissipative mechanisms in the plasma, which are presently being studied.

Mary F. Romig, USA

6913. Bunt, E. A., and Olson, H. L., "Pinhole camera" for determination of plasma arc rotational speed, *ARS J.* **31,** 6, p. 826 (Tech. Notes), June 1961.

6914. Barger, R. L., Ionization and deionization processes in low-density plasma flows, NASA TN D-740, 21 pp., Apr. 1961.

Various plasma relaxation processes that are significant in laboratory plasma flows for aerospace physics studies are discussed on the basis of a survey of time decay studies of immobile plasmas. Some of the problems analyzed and discussed are: the relative importance of the various recombination mechanisms, catalytic deionization by electronegative particles, delayed ionization produced by metastable action, and heating of the flow by deionization reactions. From author's summary

6915. Zhigulev, V. N., The theory of the "return" layer, *Soviet Phys.-Doklady* **5,** 5, 969–972, Mar./Apr. 1961. (Translation of *Dokladi Akad. Nauk SSSR (N.S.)* **134,** 6, 1313–1316, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

The interaction of a plane plasma impinging on a static magnetic field produced by external sources is considered. A theory is developed for the boundary layer (called the "return" layer by the author) between the impinging plasma and the magnetic field when the plasma velocity is relativistic and is directed perpendicular to the magnetic field. In the nonrelativistic limit rigorous solutions are obtained when the plasma consists of charged particles whose masses are all the same, and only approximate solutions are obtained when the plasma consists of ions and electrons. The results are applied to the case of a solar plasma impinging on the earth's magnetic field. The fact that the solar plasma itself carries with it the solar magnetic field is ignored by the author.

G. S. Murty, Sweden

6916. Nakagawa, Y., and Goroff, I. R., Experiments on heat transport by convection in presence of a magnetic field, *Physics of Fluids* **4,** 3, 349–354, Mar. 1961.

The effect of an impressed magnetic field on heat transport by convection has been examined with a layer of mercury bounded between two constant temperature surfaces and subject to a uniform vertical magnetic field. Experiments were performed with the strength of magnetic field varying between 1195 and 1820 gauss. In agreement with the theoretical predictions by Nakagawa, the results show that the convective heat transport is characterized by a linear function of the applied temperature difference in the neighborhood of the marginal state of stability, and the coefficient of proportionality, the Nusselt number, depends on the strength of the impressed magnetic field. From authors' summary

6917. Tidman, D. A., and Weiss, G., The effect of collisions on two-stream instabilities in a plasma, AFOSR 423 (Univ. Maryland, Inst. Fluid Dynam. Appl. Math. TN BN-234), 28 pp., Mar. 1961.

6918. Tidman, D. A., and Weiss, G. H., Radiation by a large amplitude plasma oscillation, AFOSR 479 (Univ. Maryland, Inst. Fluid Dynam. Appl. Math. TN BN-236), 10 pp., Mar. 1961.

6919. Balescu, R., Approach to equilibrium of a quantum plasma, *Physics of Fluids* **4,** 1, 94–99, Jan. 1961.

Author extends his diagrammatic method to treat irreversible processes in a classical plasma [Title source **3,** p. 62, 1960] to the case of a quantal plasma. The final results are completely analogous to the classical case. D. Ter Haar, England

6920. McLean, E. A., Faneuff, C. E., Kolb, A. C., and Griem, H. R., Spectroscopic study of helium plasmas produced by magnetically driven shock waves, *Physics of Fluids* **3,** 6, 843–856, Nov./Dec. 1960.

Measurements have been made of the temperature, density, and degree of ionization of plasmas produced by Mach 30 magnetically driven shock waves in helium (ambient pressure 1 mm Hg). Simultaneous photoelectric intensity measurements of the absolute spectral intensities of HeI λ 3889, HeI λ 5876, HeII λ 4686, and HeII λ 3293 indicate temperatures of 3.7 ev, electron and ion densities $\sim 10^{17}$ cm^{-3}, degree of ionization ~99.9%, and a density ratio of ~4 across the shock front. The estimated error is ±2% for the temperature and ±12% for the electron and ion densities. The electron density was derived independently from the width of HeII λ 4686 and agreed with the photoelectric density measurement to within the experimental error for the line width, thus providing a proof of the ionization and excitation equilibrium assumption used in analyzing the absolute intensity data. Continuum intensity measurements also provided a check on the consistency of the results. The temperature calculated from the measured shock velocity using the usual Rankine-Hugoniot equations is lower by a factor of about 2, and the density ratio is higher by a factor of about 3. A plausible explanation of this discrepancy is that ultraviolet radiation emitted by the hot plasma in the arc region is absorbed in front of the shock wave.

From authors' summary by R. A. Gross, USA

6921. Ludford, G. S. S., The propagation of waves along and through a conducting layer of gas, *J. Fluid Mech.* **9,** 1, 119–132, Sept. 1960.

Paper gives theoretical linearized analysis of (a) reflection and transmission of plane electromagnetic waves at interface between perfectly conducting layer of gas and a nonconducting atmosphere, when there is a uniform external magnetic field perpendicular to the layer; (b) existence of plane surface waves for such a layer. In connection with (a) it is shown that a finite conducting layer is transparent to waves of frequency depending upon the Alfvèn velocity and the thickness; the filtering action may bear upon propagation phenomena in the ionosphere. In connection with (b), two types of waves are indicated for layers of finite thickness; the

second is not always present. These surface waves are of interest as they tend to trap incident electromagnetic energy and transport it in direction parallel to the layer. No quantitative application of derived results is given.

R. Vaglio-Laurin, USA

6922. Carstoiu, J., Hydromagnetic waves in a compressible fluid conductor, *Proc. Nat. Acad. Sci., Wash.* **46,** 1, 131–136, Jan. 1960.

Author finds solutions for the magnetohydrodynamic equations of a nondissipative, compressible flow, and shows that the components of vorticity and current in the direction of the field only can be propogated in the same manner as Alfvèn demonstrated for incompressible flow. Further, he establishes a simple mechanical model for vorticity propagation, physically, readily comprehensible. G. V. Bull, Canada

6923. Chandrasekhar, S., The stability of non-dissipative Couette flow in hydromagnetics, *Proc. Nat. Acad. Sci., Wash.* **46,** 2, 253–257, Feb. 1960.

Author considers the general case of the stability of nondissipative electrically conducting, incompressible flow between coaxial cylinders for infinitesimal perturbations. In the limit of zero magnetic field he shows that a sufficient condition for stability is that the angular speed is a monotonic increasing function of the radius. Also of importance, author notes that Rayleigh's criterion is not recovered in the limit of zero magnetic field, and suggests that in a fluid of zero resistivity the lines of magnetic force are permanently attached to the fluid in a manner no way dependent on magnetic field strength. G. V. Bull, Canada

6924. Polovin, R. V., The motion of shock waves along a magnetic field, *Soviet Phys.-JETP* **12,** 4, 699–702, Apr. 1961. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **39,** 4 (10), 1005–1007, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

A shock wave is considered that is excited in a magnetohydrodynamic medium by a conducting piston moving along the magnetic field. The conditions are found under which the shock wave becomes nonpropagating and splits into two magnetohydrodynamic waves. The supposition is put forward that such a disintegration is one of the ways of forming filamentary nebulae.

From author's summary

6925. Kovrizhnykh, L. M., Shock waves in relativistic magnetohydrodynamics, *Soviet Phys.-JETP* **12,** 4, 725–727, Apr. 1961. (Translation of *Zh. Eksp. Teor. Fiz., Akad. Nauk SSSR* **39,** 4 (10), 1042–1045, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

The properties of a shock adiabat in relativistic magnetohydrodynamics are investigated for the case of perpendicular waves. In a number of limiting cases some simple expressions have been derived which relate the thermodynamic quantities on both sides of a discontinuity. The possibility of accelerating charged particles by means of shock waves is briefly considered. It is shown that in the ultrarelativistic case of perpendicular waves such acceleration is impossible. From author's summary

6926. Tsintsadze, N. L., and Pataraya, A. D., Cerenkov generation of hydromagnetic and magnetoacoustic waves in a rarefied anisotropic plasma, *Soviet Phys.-Tech. Phys.* **5,** 10, 1113–1121, Apr. 1961. (Translation of *Zh. Tekh. Fiz., Akad. Nauk SSSR* **30,** 10, 1178–1185, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N.Y.)

An analysis is made of the excitation of hydromagnetic and magnetoacoustic waves in a rarefied anisotropic plasma; these waves are generated by the high-speed motion of current-carrying circuits. From authors' summary

6927. Boucher, R. A., and Ames, D. B., End effect losses in dc magnetohydrodynamic generators, *J. Appl. Phys.* **32,** 5, 755–759, May 1961.

The end effect loss in a dc magnetohydrodynamic generator with rectangular cross section is considered. The case for nonconductivity walls is examined, and a simple expression for the losses in terms of the maximum power output is obtained. The end effect loss is compared to viscous and turbulent flow losses and it is shown to be the predominant loss over a wide range of operating conditions.

From authors' summary by G. L. Mellor, USA

6928. Spence, Barbara A., Bibliography on magnetohydrodynamics plasma physics and controlled thermonuclear processes, Avco Corp., Avco-Everett Res. Lab. (Everett, Mass.) AMP 36, 97 pp., Oct. 1959.

Aeroelasticity

(See also Revs. 6606, 6739, 6788, 6792, 6844)

6929. Sylvester, M. A., Experimental studies of flutter of buckled rectangular panels at Mach numbers from 1.2 to 3.0, including effects of pressure differential and of panel width-length ratio, NASA TN D-833, 37 pp., May 1961.

This paper is essentially the same as NACA RM L55130 which was published in 1955 and recently declassified. The original work was one of the first systematic studies of panel flutter, covering such variables as panel thickness ratio, aspect ratio, curvature, pressure differential, thermal gradients, buckling, damping, and dynamic pressure. The work has served as a useful paper, both for comparing with theory and for estimating design requirements. The range of some of the variables, particularly for much narrower and longer panels, has been extended in recent publications, for example, NASA TN D-451 and TN D-1058.

The subject paper discusses tests of panels clamped only at the leading and trailing edges, and panels clamped on all four edges. In general, the panels clamped on all edges were more stable; however, the susceptibility to flutter depended greatly on the buckle pattern of the panels, two half-wave buckles in the direction of flow resulting in very low dynamic pressures for flutter. It was also found that the nondimensional flutter parameter $(\sqrt{M^2-1}\,E/q)^{1/3}\,t/l$ (where M is the Mach number, q the dynamic pressure, E Young's modulus, and t and l the panel thickness and length) is a useful parameter for correlating panel flutter experiments and for design criteria. A. A. Regier, USA

6930. Mazet, R., and Chopin, S., Practical exploitation of the calculation for flutter with many degrees of freedom (in French), *Recb. Aéro.* no. 78, 41–46, Sept./Oct. 1960.

Authors discuss a simplified approach to gain further information after a flutter calculation including all important degrees of freedom has become available. It is noted that in general the energy transfer turns out to be primarily between two degrees of freedom. The interaction of these two degrees of freedom is then investigated approximately for design improvement, e.g., regarding the most efficient way to add mass or stiffen the structure if the flutter speed is to be increased. The idea is worthy of attention of practical designers. S.-F. Chen, USA

6931. van de Vooren, A. I., and Boersma, J., The aerodynamic forces of an oscillating aerofoil in two-dimensional potential flow at speeds slightly below the speed of sound (in English), Nat. Lucht Lab. Amsterdam Rap. TN W. 10, 74 pp., Mar. 1960.

By means of the analogy between boundary-value problems of two-dimensional unsteady flow and three-dimensional steady flow it is possible to calculate the indicial functions for force and moment at sonic speed due to unit steps in angle of attack and in pitch. If the speed is subsonic, it is only possible to calculate the initial phase of the indicial functions and to derive series expansions at the points where the indicial functions have discontinuites in their derivatives. It is shown that this is sufficient information to obtain by aid of Laplace transformation asymptotic expansions for force and moment of the oscillating airfoil valid for large values of the reduced frequency. Numerical results are presented for the aerodynamic coefficients for force and moment and their derivatives. R. C. Binder, USA

6932. Parkinson, G. V., and Brooks, N. P. H., On the aeroelastic instability of bluff cylinders, *ASME Trans.* **83** E (*J. Appl. Mech.*), 2, 252–258, June 1961.

The validity of quasi-steady theory, using experimental aerodynamic coefficients, to explain the observed aeroelastic instability of bluff cylinders in a uniform stream is examined for several cylinder sections. Only plunging oscillation is considered, and the analytical model is an oscillator with nonlinear damping dependent on the aerodynamic coefficients. Static and dynamic wind-tunnel tests were made of cylinder models of square, rectangular, and D-section. The D-section and the short rectangular sections behaved dynamically like the circular cylinder, showing plunge instability only near resonance with the von Kármán vortex street. In complete contrast, the square and long rectangular sections showed plunge instability with amplitude increasing with wind speed for all speeds above a critical value. These dynamic results were in quite good agreement with the theoretical predictions, using the static test data.

From authors' summary by I. E. Garrick, USA

6933. Tuovila, W. J., and Presnell, J. G., Jr., Supersonic panel flutter test results for flat fiber-glass sandwich panels with foamed cores, NASA TN D–827, 15 pp., June 1961.

Flutter tests have been made on flat panels having a 1/4-inch-thick plastic-foam core covered with thin fiber-glass laminates. The testing was done in the Langley Unitary Plan wind tunnel at Mach numbers from 1.76 to 2.87. The flutter boundary for these panels was found to be near the flutter boundary of thin metal panels when compared on the basis of an equivalent panel stiffness. The results also demonstrated that the depth of the cavity behind the panel has a pronounced influence on flutter. Changing the cavity depth from 1½ inches to 1/2 inch reduced the dynamic pressure at start of flutter by 40%. No flutter was obtained when the spacers on the back of the panel were against the bottom of the cavity.

From authors' summary

6934. Harder, R. L., Lock K., McCann, D. G., Wilts, C. H., and Royce, W. W., Supersonic flutter analyses including aerodynamic heating effects, WADC TR 59–559, 260 pp., Feb. 1960.

6935. Livanov, K. K., Stability of clamped panels in supersonic flow (in Russian), *Inzbener. Sbornik Akad. Nauk SSSR* **25,** 101–103, 1959.

6936. Lock, M. H., and Fung, Y. C., Comparative experimental and theoretical studies of the flutter of flat panels in a low supersonic flow, AFOSR TN 670 (Guggenheim Aero. Lab., Calif. Inst. Tech.), 81 pp., May 1961.

6937. LaBerge, J. G., Effect of flare on the dynamic and static moment characteristics of a hemisphere-cylinder oscillating in pitch at Mach numbers from 0.3 to 2.0, Nat. Res. Counc. Canada, Aero. Rep. LR–295, 9 pp. + figs., Jan. 1961.

Aeronautics

(See Revs. 6497, 6745, 6746, 6754, 6755, 6793, 6815, 6839, 6939)

Astronautics

(See also Revs. 6480, 6502, 6795, 6959, 6963)

Book—6938. Berman, A. I., The physical principles of astronautics—fundamentals of dynamical astronomy and space flight, New York, John Wiley & Sons, Inc., 1961, xv + 350 pp. $9.25.

Book intends to provide a concise and thorough exposition of the basic principles of astronautics, defined as the science and technology of the placement and control of manned and unmanned objects in space. Author accomplishes his aim on an introductory undergraduate level and the book for this purpose fills a gap in the mushrooming literature of astronautics. Prof. Berman attempts to teach the reader almost all subjects which are connected with astronautics, such as astronomy, astrophysics, dynamics, celestial mechanics, orbital theory, space navigation, perturbation, propulsion, vector calculus, etc. This is, of course, a rather formidable task and specialists will severely criticize the author in their own field of competence for not always quoting authentic references, for not defining terms or for giving definitions that are somewhat unconventional, for not exhibiting enough depth regarding the most recent advances, for trying to find "the solution of the Jacobi integral", for omitting well-established distance determination techniques used in astronomy, etc.

This reviewer wonders whether an elementary textbook of such a wide scope can ever be written so that it would satisfy the requirements for scientific preciseness in all the areas encompassed. The author of such a book would have to be a competent physicist, well-read astronomer, a careful mathematician, and an experienced engineer simultaneously.

Books recently reviewed on these pages and written by Brouwer & Clemence [AMR **14**(1961), Rev. 6354], Baker & Makemson [AMR **14**(1961), Rev. 3757], Ehricke [AMR **14**(1961), Rev. 4471] and Corliss [AMR **14** (1961), Rev. 6325], just to mention a few, focus their attention to smaller areas and, in this way, accomplish a more thorough job. V. G. Szebehely, USA

6939. Leitmann, G., Minimum transfer time for a power-limited rocket, *ASME Trans.* **83** E (*J. Appl. Mech.*), 2, 171–178, June 1961.

An explicit solution is found for the optimum acceleration program leading to minimum transfer time for a power-limited rocket moving between prescribed positions and velocities in a constant gravitational field. Such a flight must take place at maximum power and the thrust-acceleration components are linear functions of time. The solution is given in terms of six parameters: two for each of the acceleration components, one for the mass-flow rate and one for the transfer time; all of these can be expressed in terms of the specified boundary conditions.

The problem of rectilinear transfer in field-free space between prescribed positions and zero velocities is treated in detail and compared with results of Preston-Thomas [*J. Brit. Interplanetary Soc.* **16,** 10, 508–517, Nov.–Dec. 1958; AMR **13**(1960), Rev. 451] corresponding to constant exhaust velocity and constant acceleration programs. The minimum transfer time using an optimum linearly time-varying acceleration program is found to be some 4% less than that based on a constant acceleration program. However, the maximum velocity attained during a linearly time-varying acceleration program is approximately 1.5 times that obtained during a constant acceleration program. Therefore, more energy is needed for a minimum time transfer.

Reviewer finds the author's closing remark on the relative small gain in diminished transfer time in contrast to the significant increase in energy requirement a timely reminder to all who are involved in studies of space vehicles utilizing low-thrust propulsion systems. C. C. Wan, USA

6940. Ragsac, R. V., and Patterson, P. L., Multistage rocket optimization, *ARS J.* **31,** 3, 450–452 (Tech. Notes), Mar. 1961.

The existence is analytically shown of upper and lower bounds on the total burnout velocity obtainable with a predetermined set of values of effective exhaust velocity of each stage, disposable structure factor and number of steps. This effect stems from the existence of an upper bound that can be placed upon the Lagrangian multiplier used in conjunction with the usual analytical methods of optimizing the performance of step rockets.

Application of the found restriction seems useful in that it reduces the number of iterations required to find the correct value of the multiplier.

According to reviewer it is open to discussion whether graphical methods compare favorably with analytical techniques for optimizing multistage vehicles. A. C. de Kock, Netherlands

6941. Pines, S., Variation of parameters for elliptic and near circular orbits, *Astronomical J.* **66,** 1, 5–7, Feb. 1961.

Paper treats perturbed motion of a satellite. Author shows that by setting up and solving differential equations for the variation of initial satellite position and velocity coordinates referred to an osculating ellipse rather than for the more familiar elliptical elements customarily used in a variation of parameters approach, he is able to circumvent the difficulties associated with indeterminacies in perigee and nodal line position of nearly circular orbits of small inclination. Method has merit.

H. B. Schechter, USA

6942. Musen, P., Bailie, A., and Upton, E., Development of the lunar and solar perturbations in the motion of an artificial satellite, NASA TN D-494, 44 pp., Jan. 1961.

Paper follows the development in the analysis of the satellite perigee height and its lifetime made by Kozai and the analytical development of the disturbing function made by Cayley. These theoretical results are modified in order to permit the use of the NASA Space Computing Center methods. These modifications are based on separating the perturbations in the plane of the orbit from those off the orbit's plane and reducing the problem to the integration of the linear partial differential equation. The terms depending on the mean anomaly of a satellite's trajectory are excluded. The arrangement based on Cayley's work permits an inclusion of any trajectory's eccentricity and is valid for all its inclinations. Thus the authors investigated the influence of the combined effect of drag and lunar and solar perturbations on the orbital lifetime.

The programming work prepared and included in the paper seems important in further investigation of orbits, when the terms depending on the mean anomaly of the satellite and higher powers of the eccentricity would become more of consequence. These programs can be of importance in assessing the optimum condition for satellite launching.

The inclusion of the results of computations of the perturbations and perigee height for Vanguard I and Explorer VI gives qualitative information, and a comparison with experimental values.

Reviewer believes that the work would be more clear and useful if the authors would sum-up their conclusions at the end instead of dispersing them throughout the text.

A. Scibor Rylski, England

6943. Krause, H. G. L., Characteristic orbital variables and their time rates in unperturbed elliptic orbits, NASA TN D-558, 11 pp., Dec. 1960.

Author presents in tabular form for handy reference the many possible analytic expressions which can be developed for the orbital elements and their first two time derivatives in an unperturbed Keplerian orbit. H. B. Schecter, USA

6944. Geyling, F. T., Fundamental satellite perturbations, *ARS J.* **30,** 11, 1009–1012, Nov. 1960.

A brief exposition, from an elementary point of view, is given for some basic satellite perturbations. The treatment serves to generate independent checks of formal results from more elaborate analyses, and to establish a direct relation of these results to physical principles. Attention is given to in-plane and precessional perturbations of circular orbits resulting from oblateness, luni-solar gravitation and radiation pressure. The derivations have quantitative validity and may be extended to more general situations.

From author's summary by H. G. Lew, USA

6945. Ting, L., Optimum orbital transfer by impulses, *ARS J.* **30,** 11, 1013–1018, Nov. 1960.

The minimum impulse transfer from a given initial orbit to the final orbit of given geometry accomplished by multiple or single impulse is considered. It is shown that the total impulse will be minimum if the two orbits and the transfer trajectory are co-planar. If there is only a single impulse available, the orbital transfer can be accomplished provided that the final orbit can intersect the initial orbit at some orientations. The procedure of finding the optimum orientation is presented. With two impulses available, the orbital transfer can be accomplished without any limitation on the geometries of the initial and the final orbit. It is shown that the sum of the two impulses will be a minimum if the major axes of the two orbits and the transfer ellipse coincide with each other and are orientated in the same sense, and the apogee of the transfer ellipse coincides with that of the orbit with longer apogee distance while the perigee of the transfer orbit coincides with that of the other orbit.

From author's summary by H. G. Lew, USA

6946. Bodner, V. A., and Seleznev, V. P., Theory of stabilized systems with three self-compensation channels of acceleration due to gravity, *ARS J.* **30,** 11, 1036–1041 (Russian Suppl.), Nov. 1960.

Authors give an analysis of the systematic errors and certain other properties of gyro-stabilized inertia navigational systems operating in three dimensions. It is shown that automatic compensation for gravitational acceleration in all three channels leads to the equation

$$(p^2 + \Omega^2)^2 (p^2 - 2\Omega^2)\, \varepsilon = 0$$

for the error in each channel. The period of oscillation of the errors and their rise time constant being equal to the period of rotation of a satellite in circular orbit and the time constant of its motion with escape velocity, this is proposed as the basis of an analogy.

Such a system is unstable for arbitrary vehicle motion and the errors must be corrected continuously from extemal navigational information, or additional feedback introduced.

R. H. Macmillan, Wales

6947. Paul, E. W., The hodograph and ballistic missile trajectory problems, *Aero/Space Engng.* **20,** 2, 24–25, 70–72, Feb. 1961.

6948. Surber, T. E., On the use of quaternions to describe the angular orientation of space vehicles, *J. Aerospace Sci.* **28,** 1, 79–80 (Readers' Forum), Jan. 1961.

Book—6949. Kumosova, L. V., edited by, Artificial earth satellites (Translation of Vol. 3-5, 1959-1960 Russian editions), New York, Plenum Press, Inc., 1961, viii + 576 pp. $15.

This book is a continuation of selected Russian papers on artificial earth satellites and extends the work in Vols. I and II [AMR 13(1960), Rev. 4303] through the second lunar rocket. As in that earlier work, both the technical content and physical appearance of the book are of excellent quality. Each volume in the series includes papers varying in subject matter from analytical mechanics to physics of the outer atmosphere. Of the 37 papers in the three volumes, 14 deal with orbital mechanics and tracking, 7 with composition and density of the outer atmosphere, 5 with micrometeors, 4 with visibility of spacecraft and the remainder with cosmic ray measurements, magnetic fields, and instrumentation problems. Each paper contains a list of pertinent Russian references.

Volume 3 commences with a proof that gravitational capture of a spacecraft from earth by the moon, Venus, or Mars is impossible, at least on the first pass. The three following papers deal with satellite libration, perturbations due to a flattened earth, and perturbations due to air drag. The next presents an optimum method of search by a tracking station when a satellite has been observed on one pass, but its period is unknown. Another paper on drag perturbations is followed by a contribution to the heated controversy among theorists on impact phenomena at meteoric speeds. Among the remaining papers in Vol. 3, the most interesting to this reviewer is a report on the results of direct manometer measurements of atmospheric density with Sputnik III. The significance of variations with season, latitude, time of day, and solar activity is clearly recognized in correlating earlier Russian and U.S. data. The complete absence of vehicle design details in all articles (in contrast to quite complete circuit diagrams and photographs of instrument packages) is typified by a cryptic statement regarding the important problem of outgassing from a vehicle carrying gages to measure atmospheric composition; "the outer satellite skin was made of materials having a maximum rate of desorbtion and a minimum vapor pressure."

Volume 4 contains further contributions to many subjects dealt with in the earlier volumes: satellite mechanics, atmospheric density and composition, micrometeorites, and magnetic effects. This volume concludes with a paper on the variation with altitude of total cosmic ray flux determined from a sounding rocket fired to 200 km in 1958 and a fascinating article on "An artificial comet as a method for optical tracking of cosmic rockets." The author compares the scattering of sunlight by clouds of sodium vapor, lithium vapor, and dust that could be ejected from a cosmic rocket to produce a visible comet-like head at distances far greater than those for which the vehicle itself or even an inflated balloon could be located by telescope. Although dust might be expected to diffuse more slowly than sodium vapor, the advantage of better persistence is offset by a far lower scattering power per pound. Feasibility of using sodium was amply demonstrated with the second cosmic rocket at a distance of 120,000 km. Lithium vapor is estimated to be some 40 times more effective per unit weight than sodium, the principal gain resulting from the absence of any lithium Frauenhofer lines in sunlight.

Volume 5 deals largely with trajectories and experimental data from the cosmic and first lunar rockets. Included are some of the photographs of the far side of the moon and the data obtained in the search for a lunar magnetic field.

Readers of "Artifical earth satellites" may share this reviewer's interest in what was not included as well as what was included. No papers dealt with guidance, navigation techniques, attitude control systems, or communications. Perhaps subsequent volumes will fill this gap.

W. C. Griffith, USA

6950. Vincent, T. L., Satellite life duration, *ARS J.* **31,** 7, 1015-1018 (Tech. Notes), July 1961.

Satellites orbiting near Earth are influenced by atmospheric drag. After a sufficiently long time, the drag dissipates the total energy initially possessed by the satellite, thereby forcing the vehicle to return to Earth. The orbital decay time is determined by solving the general equation of motion using certain simplifying assumptions. The total life duration for initially elliptical orbits with eccentricities less than 0.2 and perigee heights up to 600 miles is presented in graphical form. The accuracy of the solution is estimated by comparing predicted and actual lifetimes of several recent Earth satellites.

From author's summary

6951. Juno II summary project report: Vol. I, Explorer VII satellite, NASA TN D-608, 356 pp., July 1961.

This volume covers those phases of the Juno II program dealing with the Explorer VII earth satellite. Subjects covered include selection of the experiments carried, special considerations for the launching vehicle, composition of the flight unit package, performance of the booster and upper stages during and after the firing, tracking operations, and orbital performance. Design and construction of the Explorer VII mechanical system (skin, structure, antenna reel, and antennas), electronic system (telemetry), and electrical system (networks, and battery and solar cell power system) receive extensive coverage including illustrations, charts, and diagrams. An analysis of the environmental requirements, the thermal design developed, the prototype tests to check the design, and actual flight thermal performance data are included. A chapter is devoted to prototype and flight unit testing. Each of the scientific experimenters, in separate chapters, describes the aim of his experiments, discusses the design, construction, and performance of the apparatus used, reports some of the findings, and presents a preliminary evaluation of them. An appendix describes the Juno II launching vehicle.

From summary

6952. Bjork, R. L., Meteoroids vs. space vehicles, *ARS J.* **31,** 6, 803-807, June 1961.

In order to assess the effects of meteoroids on vehicles in space, this paper summarizes current knowledge of the flux rate, mass, velocity and density of meteoroids, as well as that relative to the effects of an individual meteoroid impact. For aluminum and steel, the penetration rate as a function of armor thickness is derived. Weightwise, aluminum is found to give better protection than steel. The probability of meteroid puncture as a function of vehicle area, exposure time and armor thickness is discussed, and the results are presented in analytical and graphical form. From them, one may derive the armor weight required to protect the vehicle to any confidence level. Two examples are given exhibiting typical armor weights and the masses of the important meteoroids. In cases of uncertainty, the conservative estimate is always chosen so that the armor weights presented may be regarded as upper limits. Areas of research are pointed out wherein more knowledge might lead to weight reduction in the future.

From author's summary

6953. Jaquet, B. M., Aerodynamic characteristics at a Mach number of 3.10 of several fourth-stage shapes of the Scout research vehicle, NASA TN D-916, 17 pp., June 1961.

Results are presented of a wind-tunnel investigation made at a Mach number of 3.10 of the aerodynamic characteristics of various fourth-stage shapes of the Scout research vehicle. Comparisons are made between experiment and Newtonian and slender-body theory.

From author's summary

6954. Johnson, P. G., Miser, J. W., and Smith, R. L., Residual-load-plus-powerplant weights for orbital-launch nuclear rockets, NASA TN D-843, 26 pp., May 1961.

Charts are presented of residual-load-plus-powerplant weight as a function of thrust, specific impulse, initial weight in orbit, and mission energy for orbital-launch nuclear rockets. The initial weights range from 7600 to 226,000 pounds (corresponding to Atlas-Centaur, Saturn, and Nova boost vehicles), and missions are selected to cover the approximate capability inherent in the specified weights. Thrust is varied so that ratio of thrust to initial weight lies between 0.01 and 1.0, while specific impulse is varied from 450 to 1000 pounds per pound per second. Values of residual-load-plus-powerplant weight are computed by estimating the required weights of hydrogen propellant, tank, and vehicle structure. From authors' summary

6955. Robey, D. H., Ice in space, *J. Brit. Interplanetary Soc.* **17,** 7, 205-215, Jan./Feb. 1960.

Setting the net heat added due to radiation equal to the heat absorbed by sublimation, the steady-state temperatures and sublimation rates of H_2O, CO_2, CH_4, and NH_3 ices in space are calculated as a function of solar distance and absorptivity. For example, for a sphere of H_2O ice at a distance of one astronomical unit, steady-state temperatures of about 195°K and 147°K, and loss rates of about 0.4 inch per day and 2×10^{-5} inch per day, are calculated, respectively, for 100% and 7% absorptions of incident radiation. Suggested possible uses for ice in space include the storing of fuels and wastes, the joining and sealing of sections of space vehicles and space stations, and the protecting of bodies entering planetary atmospheres.

Explosions involving ices containing oxygen exposed to intense ionizing radiations are mentioned.

Reviewer believes that the γ (gamma) appearing on p. 211, col. 1, 4 lines from bottom should be replaced by a ζ (zeta).

E. L. Knuth, USA

6956. Shea, J. T., and Baumann, R. C., Vanguard 1 satellite structure and separation mechanism, NASA TN D-495, 13 pp., Mar. 1961.

Book—6957. Gaynor, F., Aerospace dictionary, New York, Philosophical Library, Inc., 1960, 260 pp. $6.

Ballistics, Explosions

(See also Revs. 6858, 6888, 6890, 6896)

6958. Kapur, J. N., Non-linear differential equations of internal ballistics of guns and rockets, Proceedings of the Symposium on Non-Linear Physical Problems, Univ. of Roorkee, Roorkee, India, Dec. 21-22, 1959; Kharagpur, Indian Soc. of Theor. and Appl. Mech., S. 41-S. 54.

Author demonstrates the nonlinear differential equations which arise in interior ballistics of orthodox, tapered-bore, high-low pressure, and recoilless guns and solid-fuel rockets and states the examples which have recently been solved by Jain on an electronic computer at Hamburg. These are: (orthodox gun, shot-start pressure, cord and tube propellant, pressure-index and general linear laws of burning); (orthodox gun, linear pressure law of burning, tubular propellant, bore resistance linear in the travel); (tapered-bore gun, tubular propellant, linear pressure law of burning). Results are not quoted. J. Corner, England

6959. Lutz, O., Buschulte, W., and Langemeyer, A., Concentric tubes used for geometrical configuration of solid fuel rockets (in German), Dtsch. Versuchsanstalt Luftfahrt, Ber. 132, 19 pp. + charts, 1960.

Solid propellant forms a layer at chamber wall plus one or two tubes of double thickness connected by 0 to 12 struts of double thickness. Dimensionless graphs are given, with example, for time-variation of burning area and gas channel area. Erosion and resonance are specifically excluded. Main phase of burning is studied but not combustion of the splinters, whose mass is given. Thrust and duration are quoted for a pressure-index law of burning.

J. Corner, England

6960. Price, Donna, and Jaffe, I., Large scale gap test: interpretation of results for propellants, *ARS J.* **31,** 5, 595-599, May 1961.

This report summarizes recent information and applies it to a more quantitative interpretation of shock sensitivity (gap) test values than previously available. It was found that a go in this test means that the witness plate is subjected to a shock wave of 95 kbar pressure or more; a no go at zero gap for high energy explosives and propellants most probably occurs because of the physical condition of the test material. Sensitivity ordering by shock amplitude at the end of the gap was found to be the same as that obtained from induced pressures in ten materials for which the comparison could be made.

From authors' summary by A. Levy, USA

6961. Soloukhin, R. I., Detonation of acetylene (in Russian), *Zh. Prikl. Mekh. Tekh. Fiz.* **1,** 18-20, May/June 1960.

6962. Orlow, T., Piacesi, D., and Sternberg, H. M., A computer program for the analysis of transient, axially symmetric, explosion and shock dynamics problems, U. S. Nav. Ord. Lab. Rep. 7265, 16 pp., Sept. 1960.

6963. Miller, B. P., Approximate velocity, position and time relationship for ballistic re-entry, *ARS J.* **31,** 3, 437-438 (Tech. Notes), Mar. 1961.

From a known integral of the re-entry equations, relating velocity with altitude author derives relationship between time and altitude. This involves integration of a differential equation by series expansion.

There is an error in formula [9]: in all terms of the numerator except lnu, u should be replaced by zu. Notice also that, except for an additive constant, this series represents the integral logarithm [Madelung, E., "Mathematical tools for the physicist," Dover Publications, New York, 1943, p. 32] $Ei(zu)$.

W. Liniger, USA

Acoustics

(See also Revs. 6629, 6641, 6864, 6893, 6894, 6895, 6911)

6964. Nomura, Y., and Osanai, T., Diffraction of plane sound wave by many equal circular holes arbitrarily distributed in an infinitely large rigid plane plate, *J. Phys. Soc. Japan* **16,** 4, 819-831, Apr. 1961.

Authors extend previous solutions of Nomura and Katsura [*Sci. Rep. Tôhoku Univ.* **10,** 1 (1958)] for a single hole and of Nomura and Osanai [*Sci. Rep. Tôhoku Univ.* **12,** 97 (1960)] for two holes to obtain a formal solution for an arbitrary number of equal holes. Problem is formulated in cylindrical polar coordinates. Resulting equations for the potential in the holes are solved by expansion in hypergeometrical (*sic*) polynomials. Numerical results are presented for transmission coefficient of two holes, three holes with centers on a straight line, and three holes with centers forming an

equilateral triangle, assuming in each case that the wavelength is large compared with the circumference of the hole(s). The transmission coefficient in each case tends to the sum of the transmission coefficients for the individual holes as circumference/wavelength $\longrightarrow 0$ and to the transmission coefficient of a single hole as center-center spacing/radius $\longrightarrow \infty$. J. W. Miles, USA

6965. Schuster, K., Theory of sound propagation in a channel with flow (in German), *Acustica* **10,** 5/6, 326–329, 1960.

Solutions of Navier-Stokes equations are discussed which correspond to the superposition of sound waves with laminar flow in a duct with two plane, rigid walls. Sound waves with a spatial exponential increase of amplitude are found under certain conditions. From author's summary by H. S. Ribner, Canada

6966. Avdonin, V. I., Measurements of the velocity of propagation of sound waves in saturated water vapor, *Soviet Phys.-Tech. Phys.* **5,** 10, 1180–1185, Apr. 1961. (Translation of *Zh. Tekh. Fiz., Akad. Nauk. SSSR* **30,** 10, 1245–1250, Oct. 1960 by Amer. Inst. Phys., Inc., New York, N. Y.)

A sound interferometer for the measurement of the velocity of propagation of sound waves in a saturated and superheated vapor is described, and the results of experimental measurements of sound velocity in saturated water vapor in the temperature range 50–250°C are given. From author's summary

6967. Smirnov, G. E., and Tonakanov, O. S., Fluctuations in hydroacoustic pulse signals on reflection from a water surface on which waves are present, *Soviet Phys.-Acoustics* **6,** 4, 480–487, Apr./June 1961. (Translation of *Akust Zh., USSR* **6,** 4, 482–490, Oct./Dec. 1960 by Amer. Inst. Phys., New York N.Y.)

The reflection of hydroacoustic pulse signals from a wavy surface was studied experimentally. Measurements were made under isothermal conditions on a model in a hydroacoustic tank with a regular wave and under natural conditions in a water reservoir with the presence of wind waves. In conjunction with the recording of the reflected signals the roughness of the water surface was also recorded. Rigidly secured radiating and receiving systems were used. The frequency range of the simulation measurements was from 70 to 200 kc; the natural measurements were performed at frequencies from 5 to 25 kc. A distinct correlation was found to exist between the signal and waviness of the water surface. Amplitude coefficients of variation and the magnitude of phase difference fluctuations were obtained for the reflected signals for various values of the surface roughness coefficient of the water.
From authors' summary

6968. Zakharov, L. N., Propagation of tone signals in a plane layer of water with waves on the surface, *Soviet Phys.-Acoustics* **6,** 4, 455–461, Apr./June 1961. (Translation of *Akust. Zh., USSR* **6,** 4, 454–461, Oct./Dec. 1960 by Amer. Inst. Phys., New York N.Y.)

The effect of a wavy surface on the amplitude and phase difference of acoustic tone signals propagating in a plane layer of water is considered. On the basis of a statistical analysis of the experimental data obtained, quantitative relations are established between fluctuations in the acoustic signal and amplitude of the surface wave. From author's summary

6969. Rozenberg, L. D., and Sirotyuk, M. G., Radiation of sound in a liquid with cavitation present, *Soviet Phys.-Acoustics* **6,** 4, 477–479, Apr./June 1961. (Translation of *Akust Zh., SSSR* **6,** 4, 478–481, Oct./Dec. 1960 by Amer. Inst. Phys., New York, N.Y.)

It is experimentally demonstrated at a frequency of 21 kc that the radiation resistance of a sinusoidally oscillating radiator, as measured on the electrical side, begins to fall off sharply at the instant that cavitation sets in. With a further increase in particle velocity and corresponding growth in cavitation, the specific radiation resistance attains a value of $0.3\ \rho_0 c$ and then becomes stabilized. The radiated acoustic intensity at first increases in proportion to the square of the radiator particle velocity, then its growth slackens and ceases altogether (in authors' experiments) at a level of 1.5 w/cm^2. With an increase in particle velocity above 25 cm/sec radiation intensity once again begins to increase in proportion to the square of the particle velocity, but with one third the slope as before. From authors' summary

6970. Eden, H. F., and Richardson, E. G., The propagation of ultrasonics in organic liquids under pressure. Variation of specific heat ratio and viscosity with pressure (in English), *Acustica* **10,** 5/6, 309–315, 1960.

A modified form of R. I. Tait's acoustic interferometer [AMR **11**(1958), Rev. 2363] was used to measure the speed of propagation of ultrasonic waves of frequency 3 Mc/sec at temperatures between 0 and 50°C and pressures up to 10,000 lb/inch^2. The liquids used were methyl alcohol, ethyl alcohol, chlorobenzene, fluorobenzene, bromobenzene, iodobenzene, acetone, n-hexane, cyclohexane, isopentane, and acetaldehyde. By comparing the deduced values of the adiabatic compressibility with the known experimental values of the isothermal compressibility, the specific heat ratio $\gamma = C_p/C_v$ was determined as a function of pressure for each liquid. The results are shown in tables and graphs.

An interesting point found was that cyclohexane at 19°C froze at a pressure of 4100 lb/inch^2, no discontinuity in the speed of propagation being observed.

The absorption coefficient α was measured near 30°C at a frequency of 9 Mc/sec and pressures up to 10,000 lb/inch^2, the liquids used being the four monohalogenated benzenes, acetone, n-hexane, cyclohexane, and ethylacetate. In most cases the absorption was observed to fall off in the available pressure range to about one-half of its value at atmospheric pressure. Also the coefficient of kinematic viscosity was computed from the Stokes coefficient α/f^2. R. Heller, USA

6971. Kaulgud, M. V., Ultrasonic velocity in liquid binary mixtures (in English), *Acustica* **10,** 5/6, 316–322, 1960.

Using the concept of intermolecular free length introduced by B. Jacobson [*Acta Chem. Scand.* **6,** p. 1485, 1952], the speed of propagation U of ultrasonic waves in ten liquid binary mixtures (such as acetone–benzene) at room temperature is calculated as a function of the mole fraction of one constituent and compared with the experimental value of U. The results are displayed by means of curves. Good agreement is obtained. R. Heller, USA

6972. Cook, B. D., and Hiedemann, E. A., Diffraction of light by ultrasonic waves of various standing wave ratios, *J. Acoust. Soc. Amer.* **33,** 7, 945–948, July 1961.

The theory for the diffraction of light by plane ultrasonic waves of various standing wave ratios is derived. The liquid medium disturbed by the ultrasound is considered to act as an optical phase grating. By evaluating the diffraction integral for the light amplitude, expressions for the Doppler shift, the time dependent, and the time average light intensities are found for the diffraction spectrum. Experimental measurements using two adjacent ultrasonic waves progressing in opposite directions to simulate the desired optical phase grating indicate that the theory is valid.
From authors' summary

6973. Cholat-Namy, J., Study of dynamic calibration method of pressure pickups (in French), *Rech. Aéro.* no. 80, 37–45, Jan./Feb. 1961.

Author investigates the methods suitable for dynamic calibration of pressure pickups, i.e., calibration by the shock-tube, by the ballistic wave of a bullet, and by means of a rotary pressure valve. The response of pickups with high and low frequency to the test shock load which is defined in all three cases by theory, calculation, experience and comparison, is demonstrated in curves. The completeness or incompleteness of response is discussed. It is shown that each of the methods yields results usable for certain conditions, but none can cover the whole field. The shock-tube delivers quantitative effects for certain pickups, for more difficult cases the method needs some redevelopment. The ballistic wave allows for predetermination of the class of the pickup and offers prospects for quantitative calibration of frequency. The rotary pressure valve is a handy means for small pickups with low frequency and for comparisons with pickups already known. For more difficult cases and for arriving at most reliable results it is suggested to use two or all three of the methods.

Reviewer believes that the report is a valuable help to engineers who have to use high-frequency pickups; it provides information about nature and limits of calibration as well as for realizing dependable experimental results.

W. I. E. Kamm, Germany

Micromeritics

(See Rev. 6866)

Porous Media

(See also Revs. 6652, 6710, 7006)

6974. Usenko, V. S., The experimental verification of calculated formulas of axially symmetrical filtration (in Russian), *Inzbener.-Fiz. Zb.* **4,** 1, 92–97, Jan. 1961.

This study deals with unsteady ground-water flow toward a well fed radially and by vertical infiltration from free surface. This problem was treated earlier by the same author [*Inzbener. Fiz. Zb.* no. 3, 1960]. Experimental results are given in order to verify the formula proposed by the author. The experiments were carried out under laboratory conditions in a channel of sector type having a height of 1.00 m and an outer radius of 1.25 m. The radius of the well was 1.25 cm. The material consisted of fine sand with a permeability coefficient $K = 1.09$ cm/min and the intensity of vertical infiltration had a value of 0.088 and 0.262 mm/min respectively. The comparison of the experimental results with the formulas requires especial care to be given to the determination of the coefficient of storage (free pore volume). Therefore the author pays more attention to this problem.

Author concludes the agreement between the experiments and the proposed formulas is good. One may call attention to the great scatter of the experimental points from the analytical expression, which is, of course, quite understandable due to the physical character of the phenomena. The systematic deviations, however, point to the fact that the author did not take into consideration all factors which would enable him to give a complete analysis of his experimental results.

M. M. Boreli, Yugoslavia

6975. Wageman, W. E., and Guevara, F. A., Fluid flow through a porous channel, *Physics of Fluids* **3,** 6, 878–881, Nov./Dec. 1960.

Problem considered is incompressible fluid flow in a circular pipe with uniform injection or suction through porous pipe wall. Authors attempt experimental confirmation of previously published theory for laminar flow by Yuan and Finkelstein [AMR **9**(1956), Rev. 2994]. Detailed experimental data have been omitted, as well as dimensions of experimental apparatus, thus preventing evaluation of results by reader. However, authors state that flow is in turbulent regime (exit Reynolds numbers up to 100,000).

Reviewer fails to see how laminar flow theory can be verified with turbulent flow experiments. Furthermore, discussion of modes of flow corresponding to different terms of series solution of differential equation for laminar case is incorrect because of nonlinearity.

N. H. Brooks, USA

6976. Mikhailov, G. K., On the problem of the influence of capillarity on the flow of liquid in a porous medium to a rectilinear slope of a porous mass, Problems of continuum mechanics (Volume dedicated to N. I. Muskhelishvili on his 70th birthday), Philadelphia, Soc. Industr. and Appl. Math., 1961, 275–281.

Author considers effect of height of capillary rise on flow to the surface of a porous medium, such as a dam. Solutions are presented for special cases. Author's results vary with angle of slope at which flow occurs, but show little change with changing angle of impermeable basis for the porous medium. Author notes size of moistened surface increases rapidly due to small increase in height of capillary rise when rise itself is small.

R. L. Perrine, USA

6977. Landrum, B. L., and Crawford, P. B., Effect of directional permeability on sweep efficiency and production capacity, *J. Petrol. Technol.* **12,** 11, 67–71 (Tech. Note), Nov. 1960.

It is the purpose of this paper to investigate the effect of directional permeability upon the sweep efficiency and production capacity of the five-spot and line-drive well patterns. The type of lateral variation of permeability considered is where the geological formation may be considered as an anisotropic medium with the permeability depending on the direction of flow. This paper makes use of the conventional transformation of the coordinate system as a means of removing the effect of the anisotropy. The corresponding expansion or contraction of the coordinates is utilized in conducting potentiometric model studies.

A series of results is presented for different ratios of permeabilities and for different angles between the directional permeability and the geometrical alignment of the five-spot and line-drive patterns. Considerable variation in sweep efficiency and production capacity is reported for these different conditions.

J. S. Aronofsky, USA

6978. Bean, R. J., Gilbert, R. P., and Kendall, H., On a two-dimensional free-boundary problem (in English), *ZAMP* **11,** 5, 341–355, Sept. 1960.

The problem of determining the free boundary between two fluids in a bent channel under dynamic conditions has been investigated. It is of importance to the petroleum industry to be able to determine the position and shape of an oil-water interface under such dynamic conditions. The authors made use of the following simplifying assumptions: (a) oil in oil-cap is immobile, (b) flow of water is steady, (c) oil-water bearing stratum may be represented as a bent two-dimensional channel, (d) fluids are incompressible, and (e) flow of fluids through porous media can be represented by the generalized form of Darcy's equation. An ordinary first-order differential equation for the free-boundary was obtained which, as pointed out, could be solved by a single quadrature.

J. S. Aronofsky, USA

6979. Oroveanu, T., Considerations of flow of liquid with a free surface through a nonhomogeneous porous media (in French), *Rev. Mécan. Appl.* **5,** 3, 343–365, 1960.

On the assumptions that the streamlines can be taken as horizontal and that the velocities are dependent on the depth only through the permeability, author develops the differential equation for the gravity-flow systems with the permeability varying along the depth.

Solutions for steady, two-dimensional and radial flow for different laws of variation of the permeability are given. An approximate solution for three-dimensional flow on the assumption of little variation of the permeability is given. G. Noseda, Italy

6980. Oroveanu, T., Liquid-liquid displacement in a porous medium (in French), Rev. Mécan. Appl. **5**, 5, 599–615, 1960.

Research on the one-dimensional problem of the displacement of a liquid by another (for instance petroleum by water) in a porous medium; after a general introduction, the limiting hypothesis is made of negligibility of the surface tension between the two liquids. The differential equation of the movement (already known), assuming as unknown function of time and space the saturation in water, is nearly linear. After general considerations on the problem at initial values, the particular case is studied when the initial distribution of the saturation in water is of exponential shape. The influences of gravity and of nonhomogeneity of the porous medium are examined also. D. Citrini, Italy

6981. Wright, K. R., Use of models to study ground-water problems, *Trans. Amer. Soc. Civ. Engrs.* **125**, Part 1, 133–140, 1960.

A ground-water problem was analyzed using both electrical and hydraulic analog models. The situation under study occurs along the Wisconsin River, papermill wastes being ponded on one side with an industrial water well on the other. An unconfined aquifer 100 to 130 feet thick underlies the whole system, and the purpose of the experiment was to simulate water flow in order to study the well contamination problem.

Carbon-impregnated conductive paper was cut to represent the aquifer cross section normal to the river, passing through both pond and well. Current was added and removed at all sources and sinks. Neither the density difference between fresh and waste water, nor the three-dimensional flow near the well could be represented. Little downward movement of waste from pond to the river was noted.

Medium sand represented the aquifer in the hydraulic model and flourescein dye was added to a calcium chloride solution to trace the flow from pond to well. Waste reached a minimum elevation of 1106 feet which is probably not in accord with the field situation because the effects of gravity were not properly scaled. Author claims that all features of the flow pattern checked known field conditions except that waste sinkage was minimized.

W. R. Foster, USA

6982. Todd, D. K., and Bear, J., Seepage through layered anisotropic porous media, *Proc. Amer. Soc. Civ. Engrs.* **87**, HY 3 (*J. Hydr. Div.*), 31–57, May 1961.

Paper summarizes an investigation of seepage from leveed rivers into low-lying adjoining agricultural lands. Only the flow rate and distribution of seepage as a function of the surface and subsurface boundary conditions were studied. Flow nets in idealized cross sections were determined by an electric analogy model. Boundaries represented channel bed and bank, a levee base, a lower impermeable stratum, and the water table in adjoining drained agricultural land. Variables studied include two subsurface layers of different permeabilities and anisotropies, layer arrangements and thicknesses, channel depth and width, levee base width, and water table slope.

From authors' summary by D. R. F. Harleman, USA

6983. Elrick, D. E., Transient two-phase capillary flow in porous media, *Physics of Fluids* **4**, 5, 572–575, May 1961.

The dynamics of two-phase capillary displacement in a finite one-dimensional system is considered. The problem solved is that of horizontal flow in an ideal porous medium of finite length initially at constant saturation with respect to both phases. There is no flow of one phase at each end. Experimentally, this can be achieved by membranes which are permeable to one phase but not the other. Flow is initiated by a step change in pressure of one phase at the permeable end. In order to develop a set of partial differential equations that are tractable, author makes the assumption that the permeability for both phases remains a constant value and that the saturation must be a linear function of the capillary pressure. He states that the approximations are valid if the pressure step chosen is sufficiently small. The problem then reduces to solving a set of two second-order linear partial differential equations. The Laplace transformation was used for obtaining a solution. An interesting analysis of the solution is presented. J. S. Aronofsky, USA

6984. Shvidler, M. I., Relative motion of immiscible fluids in porous media (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 131–134, Jan./Feb. 1961.

6985. Soprunenko, I. P., Stability of flow of layered fluids (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 1, 142–143, Jan./Feb. 1961.

6986. Nikolaevskii, V. N., and Rozenberg, M. D., Motion of two mutually soluble liquids in a porous medium (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 64–69, Mar./Apr. 1959.

6987. Shvidler, M. I., On the motion of the separation boundary in the transition of one-phase filtration flow to a two-phase one (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 203–204, Mar./Apr. 1959.

6988. Assaturian, A. Sh., and Chernikin, V. I., Some hydrodynamic problems of oilfield collecting pipelines (in Russian), Materialy Mezhvuz. Nauchn. Soveshch. po Vopr. Novoy Tekhn. v Neft. Promsti **3**, 183–194, 1958; *Ref. Zh. Mekh.* no. 4, 1959, Rev. 3908.

Using the Navier-Stokes equations the authors have obtained a rigorous solution for the case of steady, laminar flow of a homogeneous, viscous fluid with a free surface in an inclined, cylindrical pipe. By substituting the variables in bipolar coordinates the problem is reduced to the solution of a harmonic equation with nonhomogeneous boundary conditions. In closed form, a generalized law of the velocity distribution is presented for the case that the wetted perimeter is a circular arc. A graph is given of the relationship between the volume of a flow with a free surface, and of a full flow, depending on the ratio of the height of the segment of the live section H to the diameter D of the pipe. The pipe has a maximum flow capacity when $H : D = 0.853$.

V. V. Musatov
Courtesy Referativnyi Zhurnal, USSR

6989. Kochina, I. N., The inflow to a filter slit (in Russian), *Trudi Mosk. Neft. In-ta* no. 20, 54–60, 1957; *Ref. Zh. Mekh.* no. 4, 1959, Rev. 4037.

The two-dimensional problem is examined of the distribution of the filtration velocities over the profile of the cross section of an incomplete borehole forming a slit filter. Applying conformal transformation by the Christoffel-Schwarz equation, the expression for the complex velocity is found for the case that a circularly-bounded stratum drains a circular filter slit concentric with the external feeding contour. The presence on the feeding contour is constant. Neglecting certain small parameters, the author represents the

complex velocity of filtration on the contour of the normal cross section of the filter in the form:

$$\frac{dw}{dz} = \frac{Q}{2\pi r_c} \cdot \frac{\cos 1/2\, n\theta}{\sqrt{\sin^2 1/2\, n\alpha\pi - \sin^2 1/2\, \pi\theta}} \qquad [1]$$

where Q = filter discharge volume; r_c filter radius; $2\pi\alpha$ angular width of individual slot; n number of slots; θ polar angle of a point on the contour of the cross section. Applying the fundamental equation [1], an expression is set up for the velocity of the filtration flow along the impermeable sections of the slit filter. The expression [1] used by the author for the complex velocity of filtration on the contour of the normal cross section has appeared in an earlier paper by the Abstractor [*Izv. Akad. Nauk SSSR. Otd. Tekh. Nauk* no. 4, 121–132, 1954].

V. P. Pilatovskii
Courtesy Referativnyi Zhurnal, USSR

6990. Lanitina, A. A., An approximate method for determining the filtration resistance due to incompleteness of the borehole, in consideration of the depth of penetration of the pools into the rock (in Russian), *Trudi Vses. Neftegaz. Nauk-i. In-ta* no. 12, 265–271, 1958; *Ref. Zh. Mekh.* no. 4, 1959, Rev. 4040.

An approximation method is presented for calculating the additional nondimensional resistance caused by perforation channels in the rock. A borehole of an imperfect nature due to the method of opening is enclosed by a cylindrical surface of radius R_0, outside which the flow is assumed to be radially two-dimensional. Each pool channel within the region of the radius R_0, is regarded as a borehole of an imperfect nature in regard to the degree of opening of the stratum, draining a stratum of infinite thickness. The discharge from such a channel is calculated by the known formula of Girinsky ["Determination of the coefficient of filtration". Moscow, Gosgeolizdat, 1950]. As a result of the simultaneous solution of two equations—the equation of inflow of the liquid to a fictitiously perfect borehole, and the equation determining the discharge from a perforated borehole—found by summating the discharges of the pool channels, an analytical expression is found for the discharge from a borehole of an incomplete nature in regard to the degree of opening of the stratum. The results of calculations of the additional filtration resistance are correlated with the results of the electrical analog.

A. L. Khein
Courtesy Referativnyi Zhurnal, USSR

6991. Kolchenko, A. V., and Silin, A. A., An investigation of the process of turbo-drilling at reduced pressure in an ascending liquid flow (in Russian), *Trudi In-ta Nefti Akad. Nauk SSSR* **11**, 312–318, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7633.

Two methods of improving the efficiency of turbo-drills are investigated by reducing the liquid level in the ascending flow. In the first method, aeration of the rising liquid is effected by adding a gaseous medium to the drilling fluid forced down the borehole, with discharge through the bit; by the second method, the gas is fed through a separate pipe, discharging into the rising liquid at a predetermined level. The first method is suitable for use for drilling without a turbine at the bottom of the hole and its efficiency decreases with increasing drilling depth. The second is suitable for drilling with submerged turbo-drill and can be operated at great depths by feeding the gas into the annular clearance of the casing string, and, in shallow drilling, by feeding through the annular interspace of a jacketed casing pipe.

V. D. Sokolov
Courtesy Referativnyi Zhurnal, USSR

6992. Pogoryelov, V. I., Some problems in the hydraulic analysis of the process of filling the cylinder in a follow-up mechanism (in Russian), *Trudi Leningrad Politekhn. In-ta* no. 193, 87–93, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7705.

A more rigorous method is presented for the calculation of followup mechanisms (servomotors, hydraulic presses, etc.) in consideration of the inertia of the working fluid. Equations of motion are derived for the power element as a time function, as well as for the initial pressure in the cylinder spaces, and for the filling time of the followup mechanism.

It is demonstrated that the pressure in the cylinder space at the initial instant, as well as the filling time of the follow-up cylinder, depend on the inertia of the working fluid.

A. S. Ginevskii
Courtesy Referativnyi Zhurnal, USSR

6993. Nerpin, S. V., The influence of traces of Schwedow resistance in a fluid on its equilibrium state and motion in their layers (in Russian), *Trudi Leningrad In-ta Inzh. Vodn. Transp.* no. 25, 37–44, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7727.

A theoretical analysis of the influence of the limiting shear stress in the equilibrium of thin, fluid layers. An expression is derived for the thickness of a liquid layer on the surface of a solid body in a gravity field; the conditions for limiting equilibrium of a fluid in a porous medium are set up. Equations are obtained for the pressure distribution and the total cleavage force in the approach of two flat plates and two spherical surfaces respectively. The examples analyzed show that, in the case of motion of a liquid in very thin layers, even very small values of the limiting shear stress require consideration.

A. I. Gubanov
Courtesy Referativnyi Zhurnal, USSR

6994. Abasov, M. T., Dzhalilov, I. N., and Babanly, V. Yu., The exploitation of petroleum wells in strata with underlying water (in Russian), *Izv. Vyssh. Uchebn. Zavedenii: Neft'i Gaz.* no. 6, 61–66, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 12122.

With the object of studying the effect of the action of a selective hydraulic rupture (when an impermeable barrier is in evidence) on the increase of the water-free yield of wells in strata with underlying water, an investigation is carried out to estimate the influence of a hydraulic rupture, when confronted by an impermeable barrier, on the productivity of a well, the motion of the water-containing liquid in a homogeneous layer being steady. The radii of the impermeable barrier R_0 in the horizontal crevice are taken to be equal. The filtration region is divided into two zones. In the inner zone, radius R_0, the liquid under the impermeable barrier is assumed to have no motion. In the outer zone an inflow of liquid takes place toward the incomplete well with radius R_0 (the extent of the flow depending on the degree of completion of the well), with no bottom flow at a constant yield. In this way a formula is derived for the calculation of the increased value of a yield Q of a well with a horizontal crevice and in the presence of an impermeable barrier. In order to evaluate the influence of the hydraulic rupture (of the horizontal crevice) on the yield of a well when an impermeable barrier is present the relation is examined of the yields of the well with and without the horizontal crevice, also the relation of Q to the yield of an incomplete well (the yield depending on the degree of completion) and the relation of Q to the upper limit of the maximum possible yield free from water. The results of the computations for these relationships for different values for the thicknesses and radii of the crevice, the permeability of the collector, etc., are furnished in the form of graphs. Some practical conclusions are given on the basis of the computations.

A. L. Khein
Courtesy Referativnyi Zhurnal, USSR

6995. Danelyan, M. G., An approximate hydrodynamical analysis of individual fluid-input wells (in Russian), *Trudi Azerb. Nauk-i*

In-ta po Dobycbe Nefti no. 7, 118–135, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 12124.

This paper is a continuation of a previous investigation by A. M. Pirverdyan and M. G. Danelyan [*Trudf Azerb. Nauk-i In-ta po Dobycbe Nefti* no. 3, 139–147, 1956]. In the present paper the questions are investigated on the separate pumping of water into the stratum under the following assumptions: (1) the productive stratum consists of a number of inter-stratifications separated from each other; (2) the process of displacement is carried out in a way which will ensure that a certain amount of petroleum is left behind the displacement front, evenly distributed over the whole of the displacement zone; as a consequence the permeability to water in this zone diminishes; (3) the lines of current are only distorted in the immediate vicinity of the wells; (4) the wells opening up the multi-layered stratum are hydrodynamically incomplete. The deductions arrived at in the studies by A. M. Pirverdyan and M. G. Danelyan retain their validity in the given case.

V. A. Karpychev
Courtesy Referativnyi Zhurnal, USSR

6996. Shekhtman, Yu. M., On filtration of liquids carrying heavy hard particles (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 205–208, Mar./Apr. 1959.

6997. Hsu, B., The influence of paper compressibility on ink penetration, *Appl. Scient. Res. (A)* **10,** 3/4, 277–285, 1961.

Under the assumption that only the fibrous framework of paper is compressed by printing and that the fibers are relatively uncompressed (less than 1 part in 10^3), an equation is given for the penetration of ink into a paper as follows:

$$H = M\sqrt{\frac{2PT}{K_0\eta}}\left[1 - 2\left(1 - \frac{t_1}{10T} - \frac{t_3}{2T}\right)\sqrt{\frac{P}{P'}} + \left(1 - \frac{t_1}{6T} - \frac{2t_3}{3T}\right)\frac{P}{P'}\right]^{1/2}$$

Where: H = penetration depth
T = time of pressure duration = $(1/2)\ t_1 + t_2 + t_3$
t_1 = time of pressure rise
t_2 = time of pressure constancy
t_3 = time of pressure fall to 1/4 maximum value
M = initial hydraulic radius of a pore at zero pressure
P = maximum pressure applied
K_0 = shape factor of pores
P' = collapse pressure for zero pore space
η = viscosity

The similarity of the form of this equation to those governing penetration of a fracturing fluid into the matrix rock of an oil reservoir is striking. For a viscous fracturing fluid the penetration is proportional to the square root of pressure, the square root of time (at constant pressure) and inversely proportional to the square root of the viscosity.

In the equation given, the penetration follows the same law if the applied pressure is small compared to the collapse pressure.

For fracturing fluids, the law is the same if a filter cake of constant specific properties is built on the porous material. (See Howard and Fast, "API Drilling and Production Practice," 1957.) If a slightly compressible fluid is present, however, the penetration is proportional to pressure to the first power.

A relation relating reflectance and penetration is employed to verify the equation for penetration as a function of pressure. Agreement is satisfactory.

E. W. Hough, USA

Geophysics, Hydrology, Oceanography, Meteorology

(See also Revs. 6722, 6798, 6802, 6952, 6976, 6981)

6998. Kogan, S. Ya., On the determination of the energy of seismic waves of arbitrary form, *Bull. Acad. Sci., USSR, Geophys. Series* no. 5, 426–430, Dec. 1960. (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 5, 644–652, May 1960 by Amer. Geophys. Union, Washington 5, D. C.)

The purpose of this analytical study is to develop expressions for the energy in body and surface waves of arbitrary form when either type of wave is identifiable on a seismic record so its duration τ is known. For longitudinal body waves the Zoeppritz-Wiechert formula is confirmed, the energy being proportional to the integral $\int_0^\tau V^2 dt$ where $\vec{V}$ is the velocity of the incident longitudinal wave which generates the seismic record. For surface waves the integral is $\int_0^\tau u_x(t)\ V_x(t)\ dt = -\int_0^\tau u_z(t)\ V_z(t)\ dt$ where u_x, u_z, V_x, V_z, are, respectively, components of displacement and velocity at the surface. Both results depend on the law of conservation of energy which can most conveniently be expressed by a density of energy flow vector $\vec{q}$ whose components are $q_i = -\sum_{i=1}^{3} v_i \sigma_{ij}$ where v_i and σ_{ij} denote the components of velocity and stress respectively. The author derives this well-known result for the adiabatic process usually assumed in wave propagation. It appears also in Bullen ["Introduction to the theory of seismology," Eq. 8, Page 125].

Engineers should be cautioned that these equations are developed for families of seismic rays in a spherically stratified earth model. Body forces are assumed to vanish and diffraction effects are neglected. The energy in a ray family is propagated along a ray tube without change of wave type or energy leakage along its path. This analysis leads to a factor $\dfrac{2\pi R^2 \sin\Delta \sin e}{\cos e\left(\dfrac{de}{d\Delta}\right)}\rho a$ which multiplies the integral for longitudinal body waves (transverse waves are governed by a similar formula). In the above R is the radius of the earth, Δ the angle subtended by the entire length of a ray (where source and detector are both on the surface), e is the actual angle of emergence (and not the apparent angle of emergence), ρ the density and a the longitudinal wave speed—both at the detector.

The corresponding factor for surface waves is

$$2\pi R \sin\Delta c^3 \rho A$$

where c is the speed of surface waves. The dependence of the waves on Poisson's ratio is contained in the factor A found in the paper. The analysis in this case makes a simple but ingenious use of the properties of the Dirac function in extending the expressions for a monochromatic surface Rayleigh wave to a wave of plane arbitrary form.

Practicing seismologists are well aware of the many limitations and corrections required in applying equations of the present form to estimates of energy in wave groups identified on seismic records. The problems encountered in establishing a magnitude scale and relating it to the energy released by earthquakes are considerable (see, e.g. Chapter 22 of "Elementary seismology," by C. F. Richter). The accuracy, or rather lack of it, in equations of the type discussed in the paper can only be inferred by application

to a reasonably large sample of records. In particular, the usefulness of the equation for surface waves would be strengthened if it had been demonstrated that seismic surface waves records do satisfy the condition

$$\int_0^\tau (u_x V_x u_z V_x)\, dt \approx 0 \quad \text{developed in the paper.}$$

In view of the current great interest in seismic phenomena, reviewer believes a more careful discussion of the assumptions and limitations of the equations would have increased the utility of the paper for those whose approach to wave propagation differs from the approach traditional to seismologists.

H. A. Lang, USA

6999. Holzmann, F. M., Statistical evaluation of the reliability of the results of the grouping of signals, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12 (Translation from *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12 by Amer. Geophys. Union, Washington 5, D.C.), 1147–1153, Dec. 1960.

Author suggests a probability evaluation of the reliability of the axes of cophasality obtained in the grouping of signals. Some practical methods for the calculation of the reliability are examined. The dependence of the reliability of the axes isolated on the conditions of the experiment is investigated.

From author's summary by H. D. Block, USA

7000. Timoshin, Yu. V., On the theory of grouping, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12 (Translation from *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12 by Amer. Geophys. Union, Washington 5, D.C.), 1154–1160, Dec. 1960.

The theory of directed action of various types of grouping is discussed for an impulse system which is characteristic for seismic prospecting.

From author's summary by H. D. Block, USA

7001. Payo, G., Dispersion of Love waves along very long Euro-Asiatic paths (in Spanish), *Revista de Geofisica* **19,** 76, 341–361, Oct./Dec. 1960.

Dispersion curves, for Love waves, are determined from Spanish seismograms of earthquakes originating in Asia. These are compared with theoretical curves. Effect of thickness of earth's crust is apparent.

G. W. Housner, USA

7002. Holzmann, F. M., On the experimental analysis of interferences and of the reliability of the results of the grouping of signals, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 12 (Translation from *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 12 by Amer. Geophys. Union, Washington 5, D.C.), 1140–1146, Dec. 1960.

Author investigates the fundamental characteristics of *x*- and *t*-expressions of a signal and of an interference. Some methods of the experimental analysis of these properties are examined. It is demonstrated that the results of the grouping of signals appear to be reliable only on the condition that the spectra of the *x*-expressions of an effective signal and of the interference are separated. Some qualitative criteria of reliability evaluation are suggested.

From author's summary by H. D. Block, USA

7003. Medvedev, S. V., Investigation of the vibrations of buildings subject to seismic influence (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk SSSR* (Voprosy Inzhenernoi Seismologii no. 2) no. 5 (172), 131–192, 1959.

7004. Starodubrovskaya, S. P., Methods of approximate analysis of theoretical seismic waves arising in thin-layered media (in Russian), *Trudi Inst. Fiz. Zemli Akad. Nauk SSSR* no. 6 (173), 81–106, 1959.

Book—7005. Simmer, K., Contribution to determination of runoff relationships in natural streams [Beitrag zur Ermittlung von Gesetzmässigkeiten des Abflussvorganges natürlicher Gewässer], Koblenz, Besondere Mitteilungen zum Deutschen Gewasserkundlichen Jahrbuch no. 23, 1961, 71 pp.

Fundamental hydrologic relationships of river basins are investigated. Basins of about 80-sq mile size were selected for this study. Duration curves of precipitation and of runoff were analyzed. While precipitation duration proved to be quite regular, runoff duration curves showed a broad variance. Three types were distinguished: impermeable basin, permeable soil, and significant recharge of ground water. Maxima under 5% and minima over 95% of probability were eliminated from analysis, data were plotted on a logarithmic probability net, and analytical expressions for each of 3 types were developed, and some correlations established. This study is a first step in continuing classical hydrologic research by H. Keller, K. Fischer, and W. Wundt. Its practical purpose was to establish a basis for investigation of artificial changes in river regime by regulation, canalization, drainage and storage works.

S. Kolupaila, USA

7006. Benfratello, G., The use of a well supplied by a fresh water aquifer overlying a salt water aquifer for irrigation (in French), *Houille Blanche* **16,** 1, 32–45, Jan./Feb. 1961.

Author describes a method for salinity control in use of fresh water from an aquifer overlying a salt water aquifer. Method fits an empirical equation to salinity of produced water versus time, and derives from this an expression for salinity of mixed fresh and saline water accumulated in storage. Once limiting brine concentration and reservoir capacity are established, combined pumping and irrigation cycles can be defined for efficient use of the resource. Author's diagrams and tables permit ready use of the method.

R. L. Perrine, USA

7007. Kolesnikov, A. G., Vertical turbulent exchange in a stably stratified sea, *Bull. Acad. Sci., USSR, Geophys. Ser.* no. 11 (Translation of *Izv. Akad. Nauk SSSR, Ser. Geofiz.* no. 11 by Amer. Geophys. Union, Washington 5, D.C.), 1079–1084, Nov. 1960.

The article concerns the turbulent velocities, scales, correlations, and turbulent viscosity and turbulent heat conductivity of the sea, from the surface to about 5-meter depth, as a function of the stability criterion (Richardson number). The source of mean velocity and turbulence is wind action on the sea surface, the turbulence thus being generated in the surface layer. For description of equipment the reader is referred to earlier publications. Results are given which show the effectiveness of equipment developed for the measurement of mean velocity, temperature, vertical and horizontal velocity fluctuations, temperature fluctuations, and correlations. The data are sufficient to show a marked effect of the stability criterion on the distribution of mean velocity and turbulence and on the ratio of turbulent viscosity to turbulent heat conductivity, the effect on the ratio being to increase its value from near unity at very small values of the criterion to as much as 50 for high values of the criterion. The actual values of the criterion are not given. Some support was found for the applicability of Kolmogorov's theory of turbulent exchange to the case of a stably stratified fluid. A study of turbulent microstructure at neutral stability was made in the light of the Kolmogorov theory.

G. B. Schubauer, USA

7008. Zbrozek, J. K., and Ridland, D. M., A measured power spectrum of the vertical component of atmospheric turbulence, Aero. Res. Counc. Lond. Curr. Pap. 522, 15 pp. + figs., 1960.

Experimental studies of aircraft response to turbulent air by power spectrum methods and their theoretical account are described. A significant difference between the present measure-

ment and that available from USA reports is pointed out. Reviewer believes that the size of airplane used in the experiment has an important effect upon the results and conclusions can be drawn from experiments of wider range. He also recommends to refer to Russian literature such as; N. Z. Pinus, "Present state of problem of turbulence of free atmosphere," Trudy Central Aerologicheskoi Observatorii. no. 34, 1960.

M. Kataoka, Japan

7009. Smith, O. E., and Chenoweth, H. B., Range of density variability from surface to 120 km altitude, NASA TN D-612, 24 pp., July 1961.

This report summarizes the information on the variability of atmospheric density given in the most recent literature. Project Apollo requires a knowledge of the variability of atmospheric density from surface to reentry altitude (120 km).

From authors' summary

7010. Serbu, G. P., Results from a rocket-borne Langmuir probe experiment, NASA TN D-570, 9 pp., July 1961.

Data were obtained from a rocket-borne Langmuir probe experiment up to an altitude of 220 kilometers above Fort Churchhill, Canada, in a quiet daytime ionosphere. The electron temperatures deduced from the probe data are in good agreement with the accepted neutral gas temperatures at altitudes above 140 km. Improper corrections for the positive ion component of the diffusion current to the rocket, which component is adversely affected by the high rocket velocity, are thought to be the cause for the much higher electron temperatures measured below 140 km. The rocket-to-plasma potential was measured as 1/2 to 1 volt negative.

From author's summary

7011. Wolf, M., The present state-of-the-art of photovoltaic solar energy conversion, *Solar Energy* **5,** 3, 83–94, July/Sept. 1961.

7012. Landsberg, H. E., Solar radiation at the Earth's surface, *Solar Energy* **5,** 3, 95–98, July/Sept. 1961.

Naval Architecture and Marine Engineering

(See also Revs. 6535, 6538, 6611)

7013. Wetzel, J. M., Experimental and analytical studies of the longitudinal motions of a tandem dihedral hydrofoil craft in regular waves, Univ. Minn., St. Anthony Falls Hydraulic Lab. Tech. Pap. 30, Series B (Contract Nonr 710 (30)), 54 pp., Apr. 1960.

Experiments were conducted for a tandem vee-shaped hydrofoil craft free heaving and pitching in head and following seas with regular waves. Satisfactory agreement is found with previous data by Leehey and Steele [AMR **11**(1958), Rev. 3376]. The theoretical predictions for nonlinear, linear, quasi-steady and unsteady components following Ogilvie [AMR **12**(1959), Rev. 4248] are verified qualitatively by the experimental results. In most cases the effort in calculating unsteady effects is not warranted by the quantitative effect. In following seas the investigatd hydrofoil configuration has a dangerous tendency to undamped porpoising.

H. Thieme, Germany

7014. Newman, J. N., A linearized theory for the motion of a thin ship in regular waves, *J. Ship Res.* **5,** 1, 34–55, June 1961.

Perturbation theory is performed by systematic expansion of velocity potential and forces in powers of three—*a priori* independent—parameters (beam-length ratio, slope of oncoming wave and ship's amplitude). Author's results are more consistent than one-parameter approach of Peters and Stoker [AMR **11**(1958), Rev. 2903], who could attribute only higher-order significance to damping and added-mass phenomena, even in case of resonance.

Regarding additional resistance in a seaway author finds a new, frequency-independent term which accounts for oscillation of ship's surface within stationary Michell wave field. This term is of equal order with Havelock's drifting force and those terms found by Hanaoka and by Maruo [AMR **11**(1958), Rev. 4351]. Reviewer therefore feels the need for numerical evaluation omitted so far.

Analytical approach is based on expansion of Green's function rather than hull surface in Taylor series of deviation from rest position. Full effect of speed in advance is obtained by fixation of boundary conditions on ship's actual surface rather than on its mean position. Expressions obtained here for thin ships are consistent with reviewer's for systems of singularities [AMR **14**(1961), Rev. 3356], provided Michell's system is adequately chosen. Wave analysis yields an additional pattern, resulting from reflexion of oncoming waves on advancing ship obviously never discussed before; it obeys an inhomogeneous free-surface condition.

K. Eggers, Germany

7015. Tasai, F., Damping force and added mass of ship's heaving and pitching: Part 2, *Rep. Res. Inst. Appl. Mech., Kyusbu Univ.* **8,** 31, 39–69, 1960.

In this paper the author shows convenient figures of A and C_0K_4 which can be used for calculating the damping force, added mass and added moment of inertia of a ship heaving and pitching. The added mass and damping coefficient of nine ships were calculated by the strip method. It was found that the results by the strip method give a good approximate value. Three-dimensional correction for the damping coefficient of heave was about 20% in the neighborhood of the natural peri[illegible] Practical formulas which give good approximate values of added mass and damping coefficient in the neighborhood of natural period were obtained.

From author's summary by C. E. Carver, Jr., USA

7016. Tasai, F., On the free heaving of a cylinder floating on the surface of a fluid, *Rep. Res. Inst. Appl. Mech., Kyusbu Univ.* **8,** 32, 75–89, 1960.

In the free heaving experiments of the circular cylinder it was found that the decay curve is nearly normalized, and added mass and damping coefficient obtained from the decay slope after one cycle is in good coincidence with F. Ursell's results. In the case of a rectangular cylinder with a rounded corner, decay curve shows nonlinear characteristic slightly. In high-frequency tests the damping coefficient and added mass were larger than the theoretical values which were obtained for the forced heaving. A rectangular cylinder with bilge-keel has a smaller wave damping than the cylinder without bilge-keel. Therefore, although eddy-making resistance by the bilge-keel is moderately large, the damping coefficient is about the same as the one without bilge-keel at the natural period.

From author's summary by C. E. Carver, Jr., USA

7017. Sobolev, G. V., Damping of the rolling of a ship when in motion (in Russian), *Trudf Leningrad Korablestroit. In-ta* no. 22, 23–34, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11789.

Author derives an expression for the coefficient of damping of the rolling of a ship under way, without making assumptions introduced by other authors. The problem is divided by him into three parts: (1) The determination of the transverse vibrations of a thin wing with a span equal to double the displacement of the ship, and of a chord equal to the length of the ship; (2) the problem on the rolling of the ship under way with consideration for drift and "yawing;" and (3) the determination of the wave resistance with rolling of the ship when under way. It has to be men-

tioned that when determining the wave resistance with rolling under way the author uses the hydrodynamic theory of the rolling of ships in rough seas produced by M. D. Khaskind with all that author's assumptions. In addition it is held that on the formation of a system of waves the vessel has to waste twice as much energy as provided for in M. D. Khaskind's formula. The coefficient of wave resistance is calculated approximately. With consideration for the deductions previously made the author is able to derive a formula for the change of the coefficient of resistance to rolling.

A. K. Nikitin

Courtesy Referativnyi Zhurnal, USSR

7018. Kozlov, L. F., The problem on the determination of the resistance of a ship in the light of the results obtained from towing experiments on its model in an experimental tank (in Russian), *Sudostroenie* no. 3, 4–7, 1958; *Ref. Zh. Mekh.* no. 10, 1959, Rev. 11783.

Data are furnished on the influence of the laminar portions in the boundary layer at the surface of a model of a ship on the magnitude of the coefficient of resistance to friction of the model. Reference is made to the difficulty in determining the dimensions of the laminar portions when testing the models, and jointly with that matter to the necessity of resorting to artificial turbulence of the boundary layer. Formulas are given for the determination of the optimum diameter for the wire turbulizator and the minimum length of the ship's model, which will ensure the full extent of turbulence in the boundary layer close to the surface of the model. A formula is also derived which enables an evaluation to be made of the model's resistance because of the presence of the wire turbulizator.

Yu. M. Guliev

Courtesy Referativnyi Zhurbal, USSR

7019. Litovchin, B. D., The relationship between initial metacentric height and the capsizing angle of a ship (in Russian), *Nauchn. Tr. Odessk. In-ta Inzh. Morsk. Flota* no. 17, 71–73, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7598.

The following theorem is put: for a given ship at a given draught, the capsizing angle is the greater, the greater the initial metacentric height. The proof is founded on the use of curves of the lever arms of static stability, plotted for different values of the initial metacentric height, with other conditions the same.

The author points out that this theorem can also be proved from curves of the righting arms for dynamic stability.

V. S. Voitsenya

Courtesy Referativnyi Zhurnal, USSR

7020. Aleshkin, A. D., The influence of passive antirolling tanks on the stability of a ship (in Russian), *Sudostroenie* no. 7, 18–24, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7600.

The influence of the elasticity of the air on the flow of the working fluid in an anti-rolling tank with the air valve closed is investigated, and corrections to the restoring moment of the heeled ship are calculated, allowing for such flow. A quantitative comparison is made of the results of calculating the influence of passive antirolling tanks in a ship on its stability, when the air valves of the tanks are open and closed respectively. It is demonstrated that passive anti-rolling devices negatively influence the stability, particularly the area under the curve of static stability. It is recommended not to use valves in the communicating air ducts of such tanks but to fit special sluice valves in the water passages.

Yu. I. Ivanilov

Courtesy Referativnyi Zhurnal, USSR

7021. Pletneva-Machabeli, L. I., A system of equations for the motions of a ship in a sea, representing the relationships between rolling, pitching and heaving (in Russian), *Trudi Leningrad Korablestroit. In-ta* no. 22, 47–64, 1958; *Ref. Zh. Mekh.* no. 7, 1959, Rev. 7602.

The theory of the motion of a ship among waves is examined from the angle of A. N. Krylov's theory with the additional assumption that the straight side of the ship at the waterline encounters a regular, sinusoidal wave, in the absence of pitching and yawing. A system of three differential equations for the motion of a ship among waves is derived, embodying terms depending on three generalized coordinates, respectively representing the rolling, pitching and heaving motions.

The equations are developed to terms of the second order of smallness relative to the quantity r_B/λ, where r_B is the radius of orbital motion of the surface particles of the liquid, and λ is the length of the incident wave.

A periodic solution is found for the system of equations corresponding to steady-state motion and it is pointed out that analysis of the resonance between the parameters is reduced to investigating the stability of this periodic solution. Equations are derived for the wave periods corresponding to resonance states of the parameters. The highest critical frequency may be double the natural frequency of oscillation of the ship. Numerical examples show that terms of second-order smallness introduce a correction of 10–15% in the linear theory.

V. S. Voitsenya

Courtesy Referativnyi Zhurnal, USSR

7022. Abramson, H. N., and Dale, J. M., Sulphur ships, *Inter. Shipbldg. Prog.* **8,** 78, 57–61, Feb. 1961.

7023. Sibul, O. J., Ship resistance and motions in uniform waves as a function of block coefficient, Univ. Calif., Inst. Engng. Res. (Contract Nonr 222 (18)), 28 pp. + figures, June 1961.

7024. Lindgren, H., Model tests with a family of three and five bladed propellers—blade area ratios 0.75–1.20; pitch ratios 1.00–1.45 (in English), Medd. Stat. Skeppsprov. Anst. Goteborg no. 47, 30 pp. + figs., 1961.

7025. Pascault, J., Observations on cavitation erosion observed on the propellers of cargo and petroleum ships having a single shaft (in French), *Bull. Assn. Tech. Marit. Aero.* no. 60, 181–208, 1960.

As a result of continuous observations over a 5-year period on cavitation erosion on a certain number of cargo and petroleum ships, author comes to the conclusion that owing to the uneven field of circumferential velocities around the propeller, the shape of the propeller should be altered near the ends (between 0.7 R and R) in comparison to the case of zero incidence. As a consequence no unique form of the propeller can be adopted. The proposed changes according to the accepted ideas of the author are further explained. By comparison of prototype and model tests the similarity of phenomena has been corroborated in definite conditions of operation of the ship. Underlining the importance of a more precise construction of the propellers, some useful suggestions are given on how this can be achieved.

M. M. Boreli, Yugoslavia

7026. Lewis, F. M., Vibratory hydrodynamic forces on struts located forward of a propeller, Mass. Inst. Technol., Dept. Naval Arch. Marine Engng. DSR 5-7851, 6 pp. + charts, June 1960.

Friction, Lubrication and Wear

(See also Revs. 6620, 6705)

7027. Ling, F. F., and Weiner, R. S., A bifurcation phenomenon of static friction, *ASME Trans.* **83** E (*J. Appl. Mech.*), 2, 213–217, June 1961.

Measurements are reported of electric contact resistance, actual area of contact, static friction, adhesion and pure shear for lead on lead. The data exhibit a statistical bifurcation of friction. In other words, below extreme pressures, statistically there are two branches of the coefficient of friction versus normal load relationship. The nature of one of the branches is explicable exclusively in terms of the weld-junction or adhesion theory of friction. The nature of the other, however, is not so explicable. This points to the existence of what Holm ... called the Y-term of friction, the nature of which has yet to be satisfactorily explained.

From authors' summary by T. Ranov, USA

7028. Wahl, H., Kantenwein, G., and Schafer, W., Wear in rock drilling (laboratory tests) (in German), *Wear* **4**, 3, 234–245, May/June 1961.

Authors discuss tests of wear in rock by rotary drilling, percussion drilling, rotary-percussion drilling and rotary drilling with roller bits. New testing machines were formed for each of the flow methods of drilling, producing the typical conditions on a reduced scale. The fundamental laws of wear and drilling rate in rock are set forth. Prediction agreed well with results on full-scale drilling.

H. Majors, Jr., USA

7029. Nield, B. J., and Griffin, O. G., Relation between wear rate and debris composition in wear of wrought iron and mild steel, *Wear* **4**, 2, 111–122, Mar./Apr. 1961.

Effect of relative humidity on wear rate and debris composition of unlubricated wrought iron and two mild steels was investigated with a crossed-cylinder assembly. One cylinder was fixed and the other rotated to and fro at 94 c/min through an arc of approximately 24° about its axis. Two distinct wear-time relations were observed. One indicated an initially high rate of wear which soon decreased to a much lower constant value. This was observed with all three materials at and above 60% relative humidity. The other type of wear-time relation was practically linear. Wear-time curves obtained from tests at 20 and 40% relative humidity could not be simply classified as Type I or Type II. The wear scars formed on specimens of all three materials showed a change in appearance with change in relative humidity corresponding to the changes observed in the wear-time curves. Analysis of wear debris by x-ray diffraction suggests that the moisture content of the air is an important factor, as an increase to 20 and 40% relative humidity sees a fall in the number of debris samples containing Fe_3O_4 and an increase in the number of test periods exhibiting low wear rates.

R. Schnurmann, England

7030. Spry, W. J., and Scherer, P. M., Copper oxide film formation at a sliding carbon-copper interface, *Wear* **4**, 2, 137–149, Mar./Apr. 1961.

Experiments were conducted on copper-oxide films formed on a copper slip-ring in sliding contact with various electrographitic carbon brushes. The oxide composition was determined electrochemically to distinguish between cuprous and cupric oxide. Film thicknesses were determined by electrically puncturing the film and by electrochemical reduction. Effective temperature was measured by relating the growth rate to temperature in comparison with other rate tests on static systems. The properties of the sliding system were: (1) Each brush set was operated continuously for 48 hours on a 3-in. diam copper slip ring; (2) Sliding speed was 5200 ft/min; (3) Current density was 122 amp/in.^{2}; (4) Brush pressure was 3 lb per sq in.; (5) Cross section of each brush was 0.75 in. by 0.20 in.; (6) Surrounding atmosphere was filtered through activated carbon and maintained at 20°C and 50% relative humidity.

Authors conclude that the bulk temperature of the copper was the effective temperature for oxidation. The electric current effect on the surface chemistry was controlled by modifying the carbon brush structure. All films were composed of cuprous oxide.

Authors include in their discussion the molecular interactions and that two solids are in true contact only at a number of minute areas to explain the mechanism of friction and wear between sliding solids.

H. Majors, Jr., USA

7031. Semenov, A. P., The phenomenon of seizure and its investigation, *Wear* **4**, 1, 1–9, Jan./Feb. 1961.

A method is described for determining the seizure pressure value of two sheet specimens when indented with symmetrically-inclined punches. The maximum thickness of joined sheets near the border of junction is used to obtain minimum seizure deformation. Authors show how this method may be used to study lubricating effectiveness of various lubricants and additives and discuss mechanism of seizure of metals. Data are also presented which show that alloying metals in copper increase the seizure value appreciably.

M. B. Peterson, USA

7032. Dorinson, A., and Broman, V. E., Extreme-pressure lubrication and wear. The influence of contact stress on metallic wear, *ASLE Trans.* **3**, 2, 165–175, Oct. 1960.

The wear of a steel pin terminating in a truncated 120° cone rubbing on the flat surface of a rotating disk was studied in relation to the initial contact stress. With white oil as the lubricant, three ranges of initial contact stress were employed: 152,000–157,000 psi, 67,000–76,000 psi and 47,000 psi. Typical time-dependent wear curves for the two higher pressure ranges were multistage in character, showing first a sharp rise in the amount of wear, then a leveling-off and finally a transition to rapid wear again. At 47,000 psi initial contact stress, wear was a linear function of time. A compounded extreme-pressure lubricant was studied at 250,000 psi and at 148,000–156,000 psi initial contact stress. The time-dependent course of wear in these cases showed only two stages: the initial sharp rise and the leveling-off. The significance of the early phases of an experiment on metallic wear with respect to the mechanism of extreme-pressure lubrication is discussed.

From authors' summary by M. B. Peterson, USA

7033. Pavelescu, D., et al., Method of investigation of bearing wear with the help of radioactive isotopes (in German), *Rev. Mécan. Appl.* **6**, 1, 77–90, 1961.

7034. Tanner, R. I., Full-film lubrication theory for a Maxwell liquid, *Inter. J. Mech. Sci.* **1**, 2/3, 206–215, Apr. 1960.

A theory of full-film lubrication for a Maxwell viscoelastic fluid is developed using the concept of the absolute time derivative in the formulation of the stress-deformation law. The theory assumes a linear relation between pressure gradient and velocity and hence is valid for slightly viscoelastic fluids such as lubricating oils, for which the relaxation time is of the order of 10^{-8} sec. The problem of the load and drag of rollers with a given separation is worked out. This calculation leads to the result that the load-carrying capacity is lowered and the coefficient of friction is increased by viscoelastic effects.

J. W. Givens, USA

7035. Snopov, A. I., Plane problem of hydrodynamic theory of gas lubrication (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 6, 14–20, Nov./Dec. 1959.

7036. Kunin, I. A., Plane problem of hydrodynamic theory of lubrication, taking temperature dependence of viscosity into account (in Russian), *Izv. Akad. Nauk SSSR, Otd. Tekh. Nauk, Mekh. i Mash.* no. 2, 70–74, Mar./Apr. 1959.

7037. Hackewitz, F. W. v., Hydrodynamic lubrication of a roller bearing—introduction of parameters to obtain charts for calculation, *ASME Trans.* **83** E (*J. Appl. Mech.*), 2, 297–299, June 1961.

In a previous publication [*J. Appl. Mech.* **25**, p. 621, 1958] author proposed hydrodynamic formulas to calculate contact pressure and oil-film thickness in a lubricated cylindrical roller bearing. The present paper simplifies numerical calculations according to this method by introducing relative and dimensionless variables for the radius of the roller, oil-film thickness, and load. By aid of these variables isothermal charts were made that are suitable for rapid evaluation of operating conditions.

J. W. Givens, USA

7038. Neal, P. B., The "off" boundary condition in hydrodynamically lubricated convergent-divergent slider bearings, *Inter. J. Mech. Sci.* **1**, 2/3, 192–205, Apr. 1960.

The application of hydrodynamical theory meets with difficulty because of the negative pressures which in general are predicted, in the divergent region, if hydrodynamic continuity is assumed throughout the bearing interspace. Pertinent theoretical and experimental evidence, as to the correct boundary conditions, is reviewed and leads to the conclusion that two criteria must be satisfied, namely stability and continuity. New experimental evidence is presented which suggests that flow continuity is the overriding criterion and that stability must be satisfied within the restriction imposed by the condition of continuity.

R. C. Binder, USA

7039. Eickhoff, K. G., and White, A., The performance of ball bearings in nitrogen and carbon dioxide at elevated temperatures, *ASLE Trans.* **4**, 1, 39–49, Apr. 1961.

A test rig for life tests on ball bearings running at 100 rpm without lubrication under thrust loads is described. Performance was worse than under lubricated conditions and affected by the environment. Thus, the load-carrying capacity in nitrogen at 200°C and 250°C was only some 2% of that for lubricated operation at normal temperature. In carbon dioxide, however, at 325°C and 375°C, loads of up to 30% of the lubricated capacity were supported with deep groove, caged bearings. Stainless steel bearings performed even better. The performance of bearings in standard materials was significantly affected by temperature. Their performance at 200°C was considerably worse than at 325°C or 375°C. Treatment with molybdenum disulphide had in general no beneficial effect on unlubricated running, although it increased bearing performance in certain instances.

R. Schnurmann, England

7040. Wilcock, D. F., Orthogonally displaced bearings, *ASLE Trans.* **4**, 1, 117–123, Apr. 1961.

...This paper is directed toward the apparently neglected possibility of displacing the lobe centers of two-lobe bearings orthogonally with respect to the mid-radius of the lobe. Analysis shows that when the lobe displacement is in a direction opposite to the shaft surface motion..., and the bearing is centrally loaded, shaft stiffness orthogonal to the load vector is substantially increased. At the same time, vertical stiffness remains essentially unchanged. Minimum film thickness is decreased, particularly at low loads, while oil flow is increased. The analysis was carried out for a bearing having in cross section two arcs each subtending an angle of 150°, an L/D ratio of 1/2, and with the arc centers each displaced from the geometric center by half the radial clearance.

From author's summary by T. Ranov, USA

Books Received for Review

ALBERS, V. M., Underwater acoustics handbook, University Park, Pa., Pennsylvania State University Press, 1960, 290 pp. $10.

BAHN, G. S., AND ZUKOSKI, E. E., edited by, Kinetics, equilibria and performance of high temperature systems (Proceedings of the First Conference, Western States Section, the Combustion Institute, Los Angeles, Calif., Nov. 2–5, 1959), Washington, D. C., Butterworth, Inc., 1960, x + 255 pp. $20.

BLANCO, V. M., AND MCCUSKEY, S. W., Basic physics of the solar system, Reading, Mass., Addison-Wesley Publishing Co., Inc., 1961, xi + 307 pp. $7.50.

BOLZA, O., Calculus of variations, 2nd ed., New York, Chelsea Publishing Co., 1960, ix + 271 pp. $1.19. (Paperbound)

BROUWER, D., AND CLEMENCE, G. M., Methods of celestial mechanics, New York, Academic Press, 1961, xii + 598 pp.

CHALMERS, B., AND QUARRELL, A. G., edited by, The physical examination of metals, 2nd ed., New York, St. Martin's Press, 1960, vii + 917 pp. $32.50.

CHERNOV, L. A., Wave propagation in a random medium (translated from the Russian by R. A. Silverman), New York, McGraw-Hill Book Co., Inc., 1960, viii + 168 pp. $7.50.

CREASY, L. R., Prestressed concrete cylindrical tanks, New York, John Wiley & Sons, Inc., 1961, 216 pp. $6.75.

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